SCIENTIFIC AMERICAN SUPPLEMENT. No 1762

Entered at the Post Office of New York, N. Y., as Second Class Matter.
Copyright, 1909, by Munn & Co., Inc.

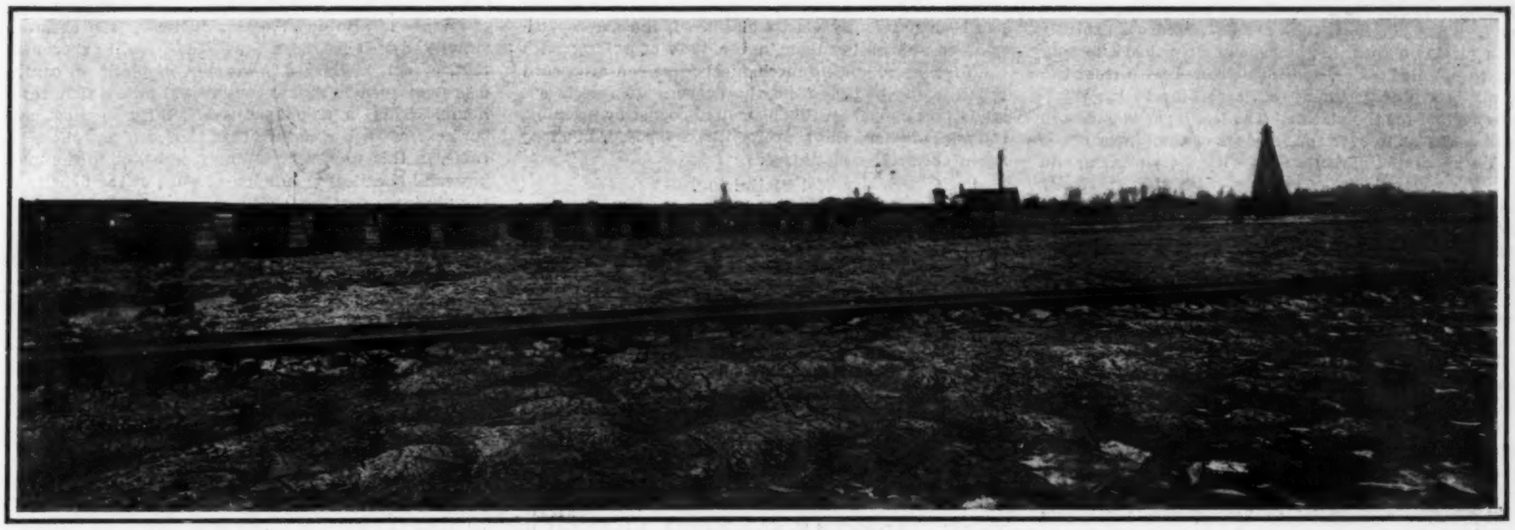
Published weekly by Munn & Co., Inc., at 361 Broadway, New York.

Charles Allen Munn, President, 361 Broadway, New York.
Frederick Converse Beach, Sec'y and Treas., 361 Broadway, New York.

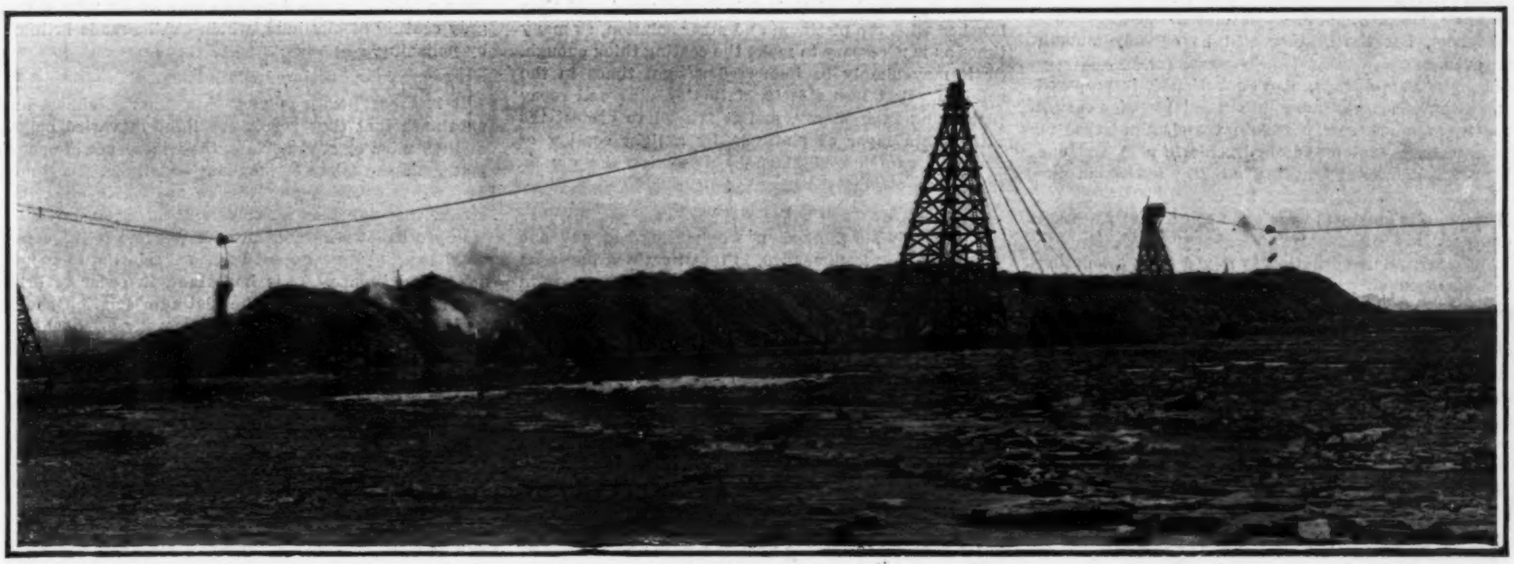
Scientific American, established 1845.
Scientific American Supplement, Vol. LXVIII., No. 1762.

NEW YORK. OCTOBER 9. 1909.

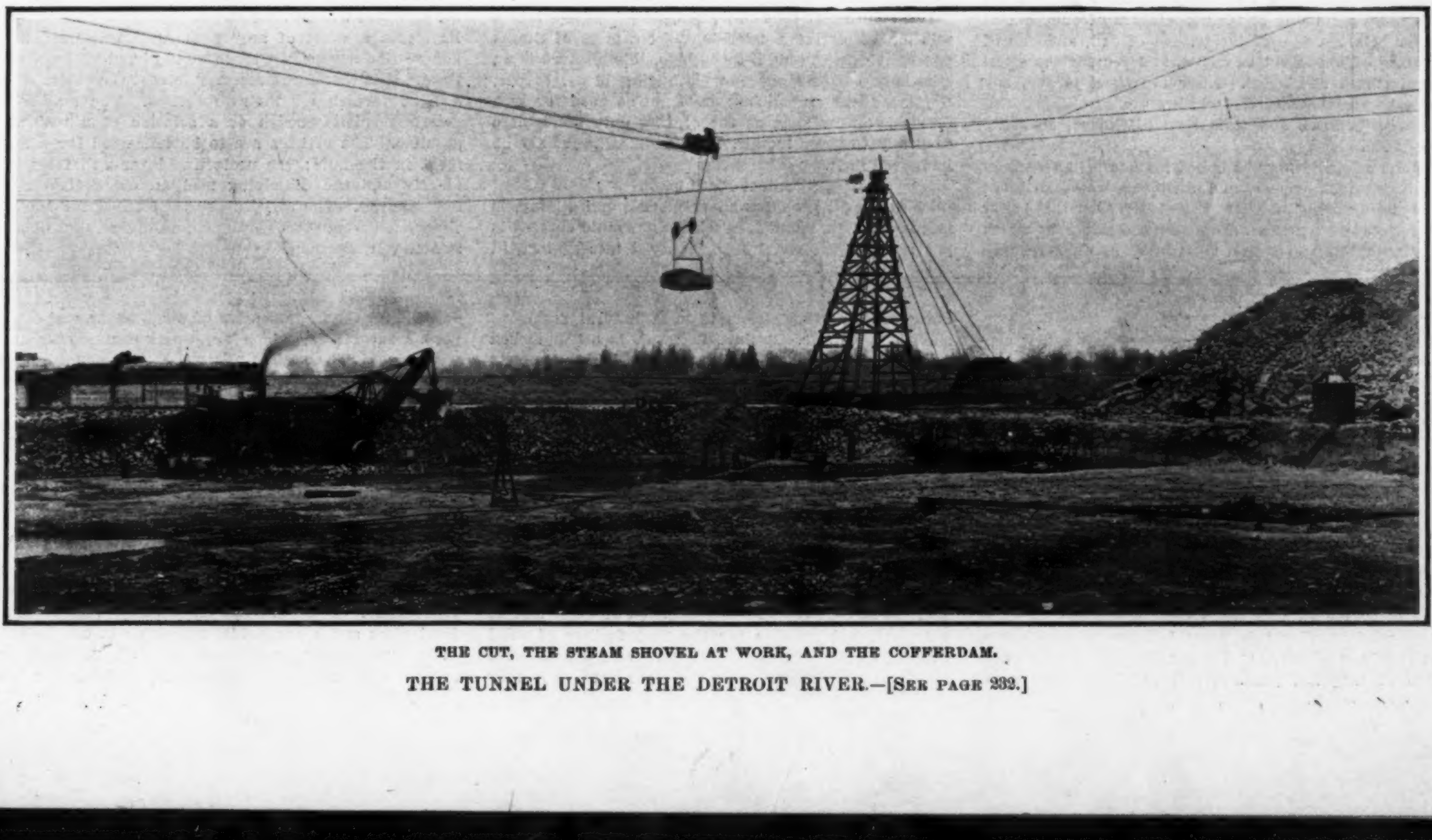
Scientific American Supplement, $5 a year.
Scientific American and Supplement, $7 a year.



A VIEW OF THE COFFERDAM.



THE ROPE TRAMWAY.



THE CUT, THE STEAM SHOVEL AT WORK, AND THE COFFERDAM.

THE TUNNEL UNDER THE DETROIT RIVER.—[SEE PAGE 232.]

PLATINIZING OR PLATINUM PLATING.

THE VARIOUS METHODS PURSUED.

BY FRIEDRICH HARTMANN.

Platinum shows more resistance to chemical action than gold, as it is harder; thus platinum plating, or platinizing, is more useful than gilding when the purpose of the plating is to protect rather than to ornament.

As a rule, only copper utensils to be used for chemical purposes are platinized. The method is as follows: Sheets of copper, from 4 to 7 millimeters thick, are heated to a mild glow (red heat), pickled in the usual manner, with dilute sulphuric acid, and scoured with sand. Thus prepared, they are powdered over thickly with platinum sponge, which has been rubbed up very fine in distilled water, and then covered with from two to six layers of platinum foil, according to the thickness desired for the plating. The last layer is put on in such a way as to overlap the edges of the copper sheet, which is covered on both sides with the platinum, and finally enveloped, for protection, with thin, perfectly smooth sheet copper which has been laid upon a very hot plate until oxidized. The edges of this are brought closely together, and the bundle is put two or three times through smooth rollers, which press it slightly, the only purpose of this being to press the platinum temporarily against the copper. It is then put into the fire, and heated as quickly as possible to a strong red heat, and put again through rollers, this time under heavy pressure. The rollers are tightened, and the rolling repeated until the sheet is twice as long as at first.

The sheet copper used for the protection of the platinum usually cracks off during the hot rolling, and the bright, smooth plate is rolled to the desired thickness. It is, however, essential to heat (anneal) it again after one or two rollings, to prevent its becoming brittle. If the work is properly done, there will be no cracks or imperfect places on the surface of the platinized sheet, but the coating will be entirely smooth and even.

The platinum sponge, above mentioned, is prepared by cutting sheet platinum into small pieces, pouring over it, in a glass or porcelain vessel, a mixture of three parts, by volume, of hydrochloric acid and one of nitric acid, and warming slightly to hasten the action. The platinum dissolves gradually, and a golden yellow fluid is obtained, which is a solution of platinum chloride.

The clear, filtered solution is mixed with a solution of ammonium chloride in water, and the result is a yellow precipitate, consisting of a compound of platinum chloride and ammonium chloride, called platinum sal-ammoniac. This precipitate is filtered, washed a few times in cold distilled water, and dried.

To produce platinum sponge from this, it is put into a porcelain vessel or small porcelain crucible and heated carefully to a strong red heat. The salt is decomposed, throwing off white fumes of ammonia, and generating chlorine gas, and metallic platinum is deposited, in the form of a spongy, very porous, dark gray mass, which, as has been said above, is rubbed to a fine powder in distilled water.

Instead of powdering the sheet of copper with platinum sponge, it can be lightly silvered, after being scoured, by rubbing it with a mixture of one part of silver chloride, two of tartar, one of salt, and one of whiting. This is put on moist, and the surface afterward rinsed and dried. After the sheet is dry, any adhering particles of the whiting are carefully blown off with bellows, and it is then platinized, as above described.

Sulphuric acid may be boiled for hours in vessels of well platinized copper, and then evaporated, without the plating being affected in the least. But this power of resistance is possessed only by a coating for which platinum foil has been used which, in its turn, was made from pure melted platinum, not from compressed platinum sponge. The latter would not be dense enough. Since, however, with the heating apparatus which we have at our command, the melting of platinum presents no difficulties, almost all the platinum foil upon the market is made of dense, melted platinum.

Platinized vessels are even more durable, though somewhat more expensive, if the copper is covered with thin sheet platinum and treated exactly as in the process of plating copper with silver. If the copper has been previously electro-platinized, the sheet platinum is welded together in the heat of rolling with the first layer, and no mechanical force can afterward separate the plating from the copper. If vessels are made (cut out) from this platinized copper by pressing, the edges, where the copper will be exposed, must be again chemically platinized.

Wet Platinizing.

Platinum, like gold, is very easily reduced, and metals can therefore be platinized by the wet method, either cold or hot.

Cold Platinizing.

A thin layer of platinum is quickly obtained on brass, bronze, copper, iron, or steel, by rubbing on to the surface, previously scoured, a moist mixture of platinum sal-ammoniac and powdered tartar. To platinize objects which are engraved, or have hollows in the surface which are not easily penetrated, the following method is good. Dissolve platinum chloride in water, and put the solution into a bottle, pour in ether, shake, and let the mixture stand fifteen minutes. The ether will absorb the platinum chloride, and become yellow; the colorless stratum beneath is the water in which the platinum chloride was dissolved.

The object to be platinized is first scoured, and then brushed with the platinum and ether solution, as many times as is necessary to make the coating thick enough. Or it may simply be immersed several times in the solution. Cast iron objects, statuettes, etc., well repay platinizing in this way, and it is well to protect the rather thin layer of platinum by a light coating of wax and paraffine, obtained by dissolving the wax in turpentine oil and the paraffine in benzine.

Hot Platinizing.

A very simple method of wet platinizing, and one which can be recommended, is that in which platinum sal-ammoniac alone is used. A solution of one part in forty parts of water is prepared, and to it is added ten parts of sal-ammoniac, and the objects, of brass, bronze or copper, first scoured, are immersed, held by wires, in the fluid, heated almost to boiling. The platinum coating is formed in a few moments, and the objects need only to be washed and rubbed with whiting, to keep them lustrous. In this case also, an application of the above mentioned wax or paraffine solution will increase the beauty of the plating.

Platinum chloride can also be used, by dissolving one part in one hundred parts of water, with eight parts of salt, heating the fluid to a boil, and immersing the articles to be platinized. The plating should be polished with whiting, as above, and is very durable.

If a solution of soda is poured, drop by drop, into a solution of platinum chloride, until a piece of litmus paper, held in the fluid, turns blue, this mixture is an especially suitable one for platinizing brass, bronze, German silver and nickel; it is not so good for iron or steel, or for zinc, as the coating does not adhere so firmly to these metals. The articles need only be immersed in it.

Contact Platinizing.

Platinizing, as well as silver plating and gilding, is more quickly accomplished when a galvanic current is generated in the metal by bringing it into contact, in the plating fluid, with another metal. The best one in all cases is zinc, and it is well to use the platinizing solution in alkaline form. Such a solution is obtained by dissolving one part of platinum chloride and twenty parts of salt in one hundred of water, and adding soda lye drop by drop until the solution has an alkaline reaction, that is, until it turns red litmus paper blue.

The article to be platinized is immersed in the bath and at once touched with a zinc rod, which has immediately before been filed bright. The resulting electrical power also considerably increases the chemical activity, and it has been proved by special experiment that, by this method, 0.22 gramme of platinum can be deposited upon 20 square centimeters in less than three hours. This is a comparatively thick coating, and surfaces of such a nature that they can be rolled, become, in this way, very strongly resistant to the most powerful chemical agents, on account of the density of the platinum coating.

Platinizing of Iron.

According to the method patented by Dodé, iron is platinized as follows: The iron is first coated with a mixture of lead and copper, made by stirring to a paste 22 parts of copper borate and 4½ parts of blue vitriol to a paste with turpentine. The article to be platinized is heated before the application, and afterward washed.

The platinizing mass is made by changing 10 parts of platinum to platinum chloride, stirring into this 5 parts of ether, and exposing the mixture to the air until the ether has evaporated, then stirring the residue to a paste with 20 parts of lead borate, 11 parts of red lead, and a little oil of lavender, and mixing this with 50 parts of amyl alcohol. The objects to be platinized are immersed in the mass, dried in the air, and heated, after which they are found to be covered with a fine gray coating of platinum, which can be made brilliant by polishing.

Colored Platinizing.

It is a peculiarity of very thin films of almost any substance that they reflect the light in varied colors, as illustrated by soap bubbles, the iridescence of opaque glass, and the colors on stagnant water, etc. Platinum, as well as other metals, can be applied in such thin strata that the play of color just mentioned results. The process is easy and inexpensive, and is frequently employed to give the most beautiful coloring to copper, brass and bronze. It is important, in order to bring out the colors well, that the platinum solution should be highly diluted, and the fluid generally used contains 1 gramme of platinum to 5 liters of water, that is, 1/5,000 of the weight of the whole.

The articles must be well scoured; they are then immersed, suspended on a copper wire, in a weak, boiling hot solution of tartar (30 or 40 grammes to 5 liters of water), and then dipped in the platinum solution, and kept constantly in motion. The change of color will take place in a few minutes, and the articles are then rinsed and dried in hot sawdust.

The coloring depends upon the concentration of the fluid, the length of time of immersion, and also upon the nature of the surface, and with a little practice, all the colors of the rainbow can be produced. The metallic strata are not of any measurable thickness, and adhere like a vapor; a touch of the hand will destroy them. It is therefore necessary to coat the object with a light varnish for their protection. The best is a colorless spirit varnish or a solution of a resin in gasoline. The articles are to be immersed for a moment in the fluid; the protecting layer will form instantly and the dissolving medium evaporates in a few minutes. The articles are then ready for sale.—Translated from "Des Verzinnen, Verzinken und Ueberziehen von Metallen."

RESINIT.

H. Lebach, in a recent article, describes a new contraction product of phenol (carbolic acid) and formaldehyde. The new product is called resinit. It resembles, but is for many purposes superior to glass, celluloid, vegetable ivory, horn, and hard rubber, and is also valuable for waterproofing fabrics. Its field of application is so extensive, that a description of the new product and its properties will be of general interest.

The amorphous substances which have been produced by various processes since the discovery of the contraction products of phenols and aldehydes by Adolf von Baeyer, in 1872, are usually designated by the collective title "artificial resins." Many of these compounds justify this name because in appearance, solubility, fusibility, and suitability for the preparation of lacquers, polishes, and varnishes, they show more or less resemblance to such natural resins as shellac, copal, etc. Resinit, however, is distinguished from both natural and artificial resins by its complete infusibility, its slow-burning properties, its insolubility in all known solvents, its resistance to chemical attack in general, and especially by its freedom from the brittleness which is common to all natural and artificial resins with the sole exception of amber. Resinit is produced by the action of potash, soda, or some other alkali or neutral salt upon a mixture of crystallized carbolic acid and a 40 per cent solution of formaldehyde. When this mixture is heated a lively ebullition takes place and a yellowish, mobile liquid is produced. This liquid, which is known as resinit mixture A, contains a large proportion of water and is, therefore, not suitable for the manufacture of solid objects, as the evaporation of the water would cause too great a contraction. On the other hand, it is very suitable for the impregnation of wood, paper, and other porous substances, which are thus made harder and waterproof. The resinit mixture B is produced from A by distilling off the water, which is partially derived from the formaldehyde solution and partly formed in the reaction. The mixture B thus produced is a viscous liquid which is capable of many industrial applications. It is quite permanent at ordinary temperatures, but by long-continued heating to 176 deg. F., followed by an increase of the temperature to nearly 400 deg. F., it is converted into a solid insoluble substance, unaffected by acids or alkalies. This is pure resinit. In this condition, resinit is a red or purple (yellow if prepared with ammonia salts), vitreous, transparent or translucent substance, with a brilliant gloss and a conchoidal fracture. It can be colored, superficially or throughout, with pigments or aniline dyes, and it is particularly suitable for the

manufacture of ornamental objects. It can be cut, turned, polished, etc., but is not yet the ideal product because it is very hard and somewhat brittle, especially when in large pieces. If, however, the resinit mixture B is mixed with a suitable filler, such as kieselgur or talcum, a product is obtained which is not transparent, but is much more elastic and more easily worked than pure resinit. It is evident, however, that for the manufacture of cheap articles, such as buttons, in large quantities the heating process occupies far too much time (at least two hours) necessitating a correspondingly great expense for molds. It was found that the process could be considerably accelerated by the employment of acids, and it is now possible to solidify resinit completely within fifteen minutes.

If a little hydrochloric acid should be added to either resinit mixture, A or B, it brings about almost the same violent reaction which acids produce in the mixture of phenol and formaldehyde, but the effect is very different when 20 or 30 per cent of starch is first added to the resinit mixture. Then the addition of dilute acid produces no apparent reaction until after long standing or on heating, so that abundant time is given to place the mass in molds or pour it on plates to stamp it, etc. After the mass is hardened, the acid is easily removed by washing with a weak solution of soda. The product thus obtained has the additional advantage of being softer, less brittle, and much more easily worked than resinit produced without the aid of acids, so that a great variety of objects can be made of it.

The coloring of resinit long presented difficulties, as pigments were remarkably changed by the process. It is now possible, however, to produce almost all colors, except pure white and very light shades.—Umschau.

THE ANALYTIC EYE AND THE SYNTHETIC EAR.

THE CONTRAST BETWEEN THE SENSES OF SIGHT AND HEARING.

BY DR. R. DEFREGGER.

It was reserved for modern science to find means for fixing and reproducing the impressions of the two most important senses, sight and hearing. Although the photographic camera and the phonograph are familiar to everyone, few are acquainted with the rôle played by the organs of sense themselves.

In the phonograph the oscillating movements of a membrane, which is set into vibration by sound waves, are inscribed upon a uniformly moving surface by means of a fine point connected with the membrane. The curve thus inscribed, when sufficiently deepened by etching, serves as a guide for a second point connected with the speaking membrane of the phonograph, which is thus compelled to reproduce the vibrations of the first membrane. The second membrane in turn produces in the surrounding air sound waves nearly or quite identical with those which affected the first membrane, and thus the words and tones spoken and sung into the phonograph are reproduced.

The ability of a little metal point to follow and reproduce all the details of polyphonal and orchestral music is surprising, for before the invention of the phonograph every musical instrument capable of producing numerous tones possessed a corresponding number of tone-forming elements; for example, the strings of a piano and the pipes of an organ. But in the phonograph one little membrane produces the whole gamut of tones separately or in any combination in such a manner that the ear can clearly recognize the component voices or parts. This is truly marvelous, but the marvel is not in the phonograph but in the ear. It must be remembered that the construction of the ear is quite similar to that of the phonograph and that the ear, apart from the inscribing apparatus, is affected by sound as the receiver of the phonograph is affected. The rôle of the receiving horn is played by the outer ear, which here also terminates in a membrane, the tympanum or ear drum. This membrane, like that of the phonograph, is connected with a system of levers composed of three small bones, the hammer, anvil, and stirrup, the function of which is to transmit the movements of the membrane to the nervous apparatus within. In the labyrinth of the ear these movements are conveyed to the nerve endings which are spread out in the cochlea, and thus the sensation of sound is evoked.

Now let us consider what happens in the receiving horn of a gramophone in making an orchestral record. There is a medley of deep and high, loud and soft tones, and of the vibrations produced by a hundred diverse instruments, all represented by alternate condensations and rarefactions of the air, or by to-and-fro movements in the direction of the axis of the horn. Let us regard the last thin layer of air in contact with the membrane, or, which amounts to nearly the same thing, the membrane itself. This, of course, cannot follow the individual movements, of various velocities and intensities, but only the resultant of all these movements. This resultant is also an undulatory movement, but no longer the simple pendulous movement of a waving field of grain, but rather a complex of trains of waves of the most diverse character and apparent irregularity. It can best be compared with the motion of a storm-tossed sea. Here, also, we have a series of great waves overlaid by smaller waves and ripples, and the individual particles of water are driven simultaneously by diverse impulses, so that their up-and-down movements are the resultants of the effects of the entire chaos of waves. The complicated movement of the ear drum is automatically resolved in the ear into the separate harmonic movements which produced it.

In this puzzling ability of the ear to analyze automatically the most complex combinations of tones and to hear the single tones separately lies the true marvel, not in the phonograph, which simply fixes and reproduces the movements. We cannot here discuss the hypotheses which have been elaborated for the explanation of this analytical power of the ear, and concerning which scientists were long at variance. We shall only point out that the classical theory of resonance developed by Helmholtz has failed to stand the test of recent anatomical and physiological investigations. The phonograph simply records the curves of resultant motion existing in the receiving horn and likewise in the external ear. When this movement is reproduced by the speaking membrane, the ear is again called upon to analyze it into its simple harmonic elements.

As the phonograph may be regarded as the archives of auditory sensations, so photography represents the archives of visual sensations. There is a temptation to draw a parallel between the youngest branch of photography, photography in natural colors, and the phonograph. Everyone who is acquainted with the three-color process of photography is struck by the marvel of reproducing, with the aid of three very harsh colors, every possible tint of the spectrum. We will confine our attention to the Lumière autochrome process, which is both the newest and the most convenient process of photography in natural colors. Here the photographer has nothing to do with colors. He exposes and develops the plate, submits it to a few other purely chemical processes, and the picture is finished. The colors are present in the form of an exceedingly fine mosaic of green, red, and blue-violet dots, which are distributed over the plate, and the colored picture is produced by covering some of these dots by the photographic image. A red spot in the picture is produced by covering all the blue and green dots at that point and allowing only the red dots to show. The most remarkable feature is that the combination of these brightly colored dots, which are so small that they cannot be seen separately by the naked eye, is able to reproduce with almost absolute correctness every tint and shade of the natural object. And this marvel resides in the operations of our organ of vision. If two or more lights of different colors act simultaneously upon the eye, we do not see the colors separately, but receive the impression of a color different from either. If, for example, a sheet of paper is illuminated by a blue and red lantern, the paper appears neither blue nor red, but violet. In other words, we have a single color impression which cannot be distinguished from that of a paper illuminated by a violet lantern. Nor is it necessary that the resultant color should have, as it happens to have in the above example, any real or apparent resemblance to either of its components. This is true only of certain selected pairs of colors, such as blue and red, blue and green, yellow and red, yellow and green. If, however, a sheet of white paper is illuminated simultaneously with red and green light, the general impression produced conveys no suggestion of red or green. The resultant tint is white or yellow or, in some cases, a gray, dotted with red or green. This same appearance of more or less pure white is produced by the combination of blue and yellow light. This statement appears to contradict the common experience that "blue and yellow make green"; but the latter observation is based upon the mixture of pigments, while we are dealing with colored lights. A mixture of a yellow and a blue pigment forms a green pigment, because green is the only color which is transmitted by both red and blue pigments.

Light of a single color (monochromatic light) almost never occurs in nature. Almost without exception we have to do with light of mixed colors. All our so-called simple colors, such as vermilion, sky blue, and leaf green, transmit to the eye a long series of simple tints, and may be compared to the sound produced when all the keys of an octave of a piano are struck at once. The visual impression, however, is not discordant, like that received by the analyzing, tone-resolving ear, but it is the impression of a simple color. This phenomenon leads to the explanation of photography in colors. As, in our vision of colored natural objects, the proportions of blue, red, and green in the infinite series of tints are not perceived separately, but are blended to form a totally different color, a similar process takes place in our vision of the small colored photograph. The mixture of colored light, presented to the eye in the form of a mosaic of fine dots, must reproduce the impression of the same color that the natural object itself produces, or, in other words, all tints of nature are reproduced by the photograph.

If, for example, we photograph with an autochrome plate a yellow sunflower, with its green stalk and leaves, the yellow of the flower, which is characterized by containing red and green but no blue rays, is reproduced in the picture by covering all the blue dots and leaving the red and green dots uncovered. If the red is slightly dimmed, the preponderance of green produces a cold greenish yellow, while if the red dots are partly covered the preponderance of red produces an approximation toward orange; similarly, in the reproduction of the green leaves and stalk. In general the green dots are exposed, the blue and red dots are covered, but the correct gradation of color is brought about by slight admixtures of red or blue. The addition of red makes the green brighter and more yellowish, while blue makes it darker. If the process is so conducted that the interaction of the component colors takes place to the same degree as in nature, all possible colors will be correctly reproduced. That this absolute correctness of reproduction has not yet been attained is not surprising in view of the newness and difficulty of the process.

This comparison of these two important modern inventions, the phonograph and the photograph, illustrates the contrast between the senses of hearing and sight. While the ear unravels and analyzes the chaos of sound waves which falls upon it, and perceives all the simple harmonic components separately and distinctly, the eye has the power of combining partial impressions into a new compound impression, or in other words of working sympathetically and presenting to our consciousness a great variety of tones compounded of three colors submitted to the eye in various definite proportions. Our impression of the universe would be curiously different if the functions of these two organs were interchanged, so that the ear performed a work of analysis, and the eye a work of synthesis.—Translated for the Scientific American Supplement from Prometheus.

Considerable finds of asbestos have been made in the Urenberg district, covering large areas and of great body and fine quality. The discovery refers to two places named Peyan-Tchin and Ak-Zigit respectively, the area of the latter asbestiferous ground being estimated at 48 square versts. The deposits are found in the form of large strata of serpentine lying among silicious schist and porphyry. The strata are intersected by many veins of serpentine which contains the asbestos.

These veins in many cases rise right to the surface, and where the ground is stony and there is no soil on the top they are quite visible. The veins extend to various lengths, varying from 350 feet to 1,400 feet and even 2,100 feet, and it has been found that at that depth the mineral does not change in form and that the quality rather improves. The fiber taken singly seems to be quite white, but in the bulk the color is olive green. It is beautifully soft and woolly. The land on which the discovery has been made is in the Orsk district.

THEORY AND PRACTICE OF ILLUMINATION.*

SOME PRACTICAL CONSIDERATIONS.

BY THOMAS W. ROLPH.

In any branch of engineering, practice usually precedes theory. As practice develops and becomes more widespread, its faults show themselves, and in the attempt to remedy these faults the theory is evolved. Theory reacts upon practice, improving it, and practice in turn reacts upon theory, causing a development of shorter methods of predetermining results.

Thus, in the field of illumination practice is several thousand years old, but the theory is only beginning to be developed. The development of the early forms of illumination was not accompanied by any great increase in intrinsic brilliancy or intensity of light per square inch of lighting surface. The fire brand of the savage naturally led to the use of the pine torch for illumination. This in turn was succeeded by candles and oil lamps. Until the introduction of illuminants more efficient than these, the intrinsic brilliancy of the light-source remained very low. The quantity of light which could be obtained from a single light-source also remained low, and to illuminate large areas large numbers of light-sources were necessary. It was a simple matter to place these lights where desired. With the development of gas and electric lights, whose locations are more or less permanent, faults of location began to be apparent. Candles or oil lamps could be moved to the part of the room in which the light was wanted. For example, in a bedroom they could be placed near the mirror when it was in use. Generally speaking this is impracticable with gas and electricity, however, and in order to obtain the light at the proper points, it is necessary to either flood the room with light or to locate the lights where light is desired. The former is undesirable from the standpoint of economy, and hence arose the study of light location as a part of the work of the designer of lighting systems. Another important factor in the development of illumination was the decreased cost of the production of light, which led to a wider use and therefore raised the standard of illumination. Consequently the use of lights with regard to efficiency of operation and the placement of lights with regard to uniformity of illumination attracted the attention of the workers in the field.

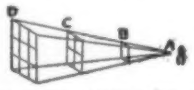


Fig. 1.—LAW OF INVERSE SQUARES.

At this point theory of illumination began to be developed. Methods of changing the natural distribution of light-sources were introduced; then methods of measuring the intensity of light and of calculating the amount of light necessary to obtain the required illumination, were brought out. The early calculations were necessarily laborious and were, therefore, not widely applied. Improvements have been made, but it is only within the last two or three years that these improvements have shortened the methods of calculations sufficiently to cause their widespread application. Conditions are now such that it is a commercial proposition to apply illumination calculations to practically every problem of any size. The conditions of lighting in this country are, therefore, gradually improving, although it is no exaggeration to say that over half of the lighting systems in use to-day could have their efficiency materially increased without in any way detracting from the artistic results obtained. This is due both to the increased efficiency of modern illuminants themselves, and to improvement in the location and equipment of them.

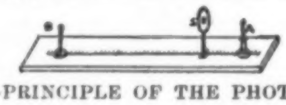


Fig. 2.—PRINCIPLE OF THE PHOTOMETER.

In considering the theory of illumination, we must first consider the purpose of illumination. Its principal object is to enable the eye to see comfortably the objects illuminated. Here at once we perceive two factors: first, the human organ upon which the effect is produced, viz., the eye; second, the factor which produces this physiological effect, viz., light.

Considering light first, it may be defined as those particular vibrations of the ether whose wave-lengths measure between 0.00004 of a centimeter and 0.00008 of a centimeter. The visible spectrum lies between these limits, the violet rays being the shortest, and the red rays the longest. When the colors composing this spectrum are combined in about the same proportions, as in daylight, the effect upon the eye is that of white light. This is the combination of colors ordinarly striven for in artificial light-sources.

Light itself is invisible, and by this is meant that we cannot see light rays unless they pass into the eye. For example, the beam of a searchlight would be absolutely invisible when viewed from the side, were it not for slight particles of dust in the air which reflect portions of this beam back to the eye. To see any object, then, we must have light falling upon this object and reflected from it to the eye.

Illumination as a branch of engineering is peculiarly distinctive inasmuch as it involves effects upon a human organ. To understand the problem, we must consider the construction of this organ. Fig. 7 is a rough drawing of the construction of the eye. It is similar to a camera. In the figure, *i* is the iris or diaphragm which forms the colored portion of the eye; *p* is the pupil, or opening through which light passes; *l* is the lens for focusing the picture; *r* is the retina and corresponds to the plate or film of the camera. The central portion is called the vitreous humor and consists of a transparent fluid filling the inner portion of the eye, and serving to maintain the shape of the eye. The action of both the lens and the iris is automatic. The muscles moving the lens automatically focus the object to be seen, upon the retina. In the eye this focusing is accomplished by changing the shape and consequently the focal length of the lens. In a camera the focal length of the lens never changes, and focusing is accomplished by a change in the distance from the lens to the plate or film. The iris determines the amount of light to be allowed to pass into the eye. It corresponds to the stops of a camera. For example, when the light becomes very intense the iris automatically closes as far as possible. Photographers know that the smaller the stop in the camera the sharper the definition will be in the picture. This is also true of the eye. When the illumination is very low and objects are dimly lighted, the iris is open to its widest extent, to allow as much light as possible to pass in. The outlines of objects are then indistinct and hazy, showing that they are not focused perfectly upon the retina. Brilliantly illuminated objects, on the contrary, stand out very sharply and distinctly. This does not mean, however, that a bright object such as a filament of an electric lamp would stand out distinctly, for here the brilliancy is so great that the iris shuts out as much light as it can, and yet cannot shut out enough to prevent a strain of the retina and consequently poor vision.

For the protection of the eye there are several points which should be considered in designing lighting systems. The following are the most common causes of injurious effects:

1. Too little light. 2. Too much light. 3. Glare. 4. Flickering. 5. Streaks or striations. 6. Extreme contrasts. 7. Reflection from polished surfaces.

The first two of these are easily taken care of by the calculations of the engineer.

Glare is a common fault in lighting systems, and it has worked untold injury to the eye. Witness in theaters and public halls the many lighting systems with bare lamps directly in the field of vision and often so arranged that the audience must look past or nearly at them in order to see the stage or platform. Some of these systems of lighting appear to have been designed with the special object of adding to the prosperity of the oculist. Two simple considerations will be the means of eliminating these injuries. First, keep the light-sources as far as possible above the direct range of vision—no economy is sacrificed by this, if correct reflectors are used. Second, diffuse by a globe or reflector the light from sources of high intrinsic brilliancy.

It was previously stated that the action of the iris of the eye is automatic. In its motion, however, there is an appreciable time factor and a change in the intensity of the illumination on a surface does not cause an instantaneous change in the size of the pupil. Herein lies the injury worked by a flickering light-source, for before the eye can adjust itself to a given intensity of illumination, the intensity has changed. The most common example of flickering is the ordinary arc lamp.

Streaks or striations are caused by reflection from a polished metal surface. A polished aluminium reflector will produce brilliant streaks on a surface illuminated by it. The attempt of the eye to adapt itself to two conditions of illumination at the same time cannot fail to be harmful.

An illustration of eye strain caused by contrasts is in the illumination of a bookkeeper's desk. It is not uncommon to find a light source with a concentrating reflector, brilliantly illuminating one book, while another book continually referred to is supposed to be illuminated by the same light. The quantity of light on either book may be sufficient for comfortable vision, but the necessity of a continual change in the size of the iris is a strain on the muscles. Reflection from polished surfaces is regular reflection. By regular reflection is meant the direct reflection of light. The extreme case of regular reflection is that of mirrors, but any glazed paper causes it and only a very rough surface, such as blotting paper, does not give some direct reflection. Unless the light is properly placed, this causes a brilliant spot on the paper worked upon, and consequent injury to the eye. In desk lighting this can be avoided by placing the light-sources not in the middle of the desk or directly in front, but at the left.

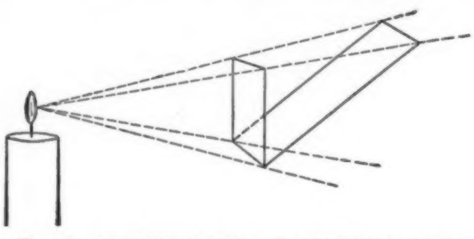


Fig. 3.—ILLUSTRATING LAMBERT'S LAW.

The desirability of obtaining the correct intensity and distribution of illumination and of obtaining this in an efficient manner, necessitates the use of lighting calculations. In considering these calculations we must first consider the fundamental units of light and illumination. Of these, the most widely used is the candle-power or unit of intensity of light. It should not be confused with quantity or with any idea of distance. If a lamp gives a certain candle-power in any particular direction, the candle-power is the same no matter what the distance may be. It is not intensity of light, but illumination which is affected by distance from the light. The unit of quantity or flux of light is the lumen. A third unit in common use is the unit flux-density or intensity of illumination, and is the foot-candle. Flux-density varies inversely as the square of the distance from the light-source when the latter is a point. This is illustrated in Fig. 1.

The emission of light from a point may be considered analogous to a spreading stream of water issuing from the nozzle of a hose and affected by no other forces. Since there are no other forces acting, each particle will travel indefinitely in the same direction. Candle-power of light is analogous to the speed or velocity of the water. It is the same at all distances from the nozzle or light-source. Flux or quantity of light is analogous to the quantity of water which the nozzle sends out in a unit of time. This is also a constant quantity for any particular condition of flow. Flux-density is analogous to the quantity of water which would strike a unit of surface in a unit of time. For example, in Fig. 1 a unit of surface one foot from a point-source of light of one candle-power has a flux-density or intensity of illumination of one foot-candle. Two feet from the source of light the surface over which the same flux of light is spread is four times

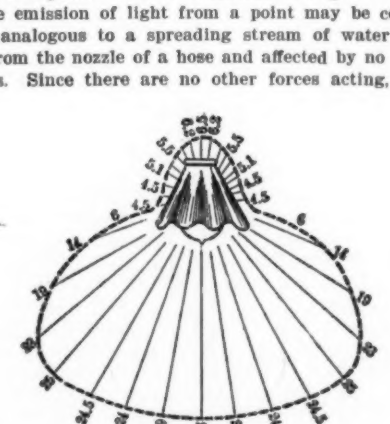


Fig. 4.—PHOTOMETRIC CURVE OF OPAL REFLECTOR.

* Journal of the Franklin Institute.

as great, and the average flux-density is therefore only one-fourth of one foot-candle. We may, therefore, write the formula which is used as the basis of one method of calculating illumination

$$I = \frac{CP}{d^2}$$

where I is the flux-density in foot-candles, CP is the intensity of light in candle-power, and d is the distance in feet from the light-source to the point considered. Although rarely appreciated, the fact must not be overlooked that the candle-power, foot-candle, and lumen

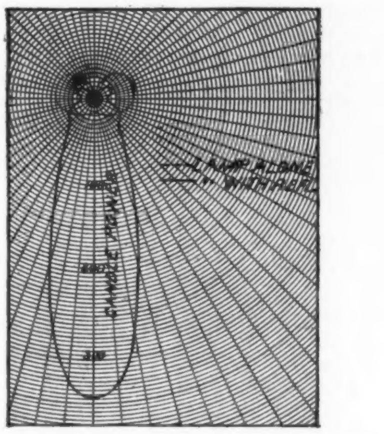


FIG. 5.—50 WATT, 48 C. P. BOWL-FROSTED TUNGSTEN LAMP WITH HOLOPHANE REFLECTOR NO. 9651.

are essentially rates, and hence involve in themselves the element of time. For example, the lumen is defined as the quantity of light passing a unit area in one unit of time. Rates cannot be bought and sold, but quantities can. Lumens, or that which is used to produce them—kilowatts—cannot be bought and sold, but lumen-hours or kilowatt-hours can be.

In deducing the equation given above, we have considered light striking a surface perpendicularly. When the surface is inclined to the direction of light, a given flux is spread over a larger area as illustrated in Fig. 3. The flux-density or illumination is therefore decreased, and this decrease is proportional to the cosine of the angle. This is known as Lambert's law, and introducing it into the formula we have

$$I_h = \frac{CP \cos\theta}{d^2}$$

where I_h is intensity of illumination on a horizontal plane as distinguished from a plane normal to the direction of the light rays, and θ is the angle which the ray of light makes with a line perpendicular to the horizontal plane.

This is the formula used for determining the flux-density or intensity of illumination in foot-candles at any point on a horizontal plane. The formula with θ equal to 0 forms the basis of the photometer or instrument for measuring light intensity. The measurement is accomplished by balancing the illumination from the light-source being measured, against the illumination obtained from a standard light-source, and then introducing into the equation the squares of the distances from each light-source to the comparison screen. This principle is illustrated in Fig. 2 and forms the basis of practically all photometers, although the more elaborate instruments are complicated by various devices for obtaining precision and ease of operation. By means of the photometer we can obtain the candle-power or intensity of light of a light-source in any direction.

Fig. 4 shows a photometric curve. This curve is found by a photometer and shows the candle-power of light in all directions, in a vertical plane, from directly underneath the light-source to the point directly above the light-source. In obtaining these values the lamp and reflector were considered as a single point of light, and since the comparison screen was at a distance of 10 feet from the lamp and reflector, the assumption of a single point introduces but little error. Fortunately, the intensity of light of most of our light-sources is the same in any direction in any particular horizontal plane. The distribution in a vertical plane, therefore, shows the intensity in every direction. Very slight errors are eliminated by making this a test in the mean vertical plane. To obtain these mean values, the light-source is rotated about its axis during testing at such a speed that each candle-power reading is the average reading for the horizontal plane in which it is taken.

As a representation of the quantity of light emitted from a source, the photometric curve is exceedingly deceptive. The natural tendency in considering a curve of any kind is to regard the area as a representation of quantity. In Fig. 5 at first sight it would appear that the curve of the lamp and reflector shows a greater amount of light than the curve of the bare lamp. This is not true; the candle-power of the lamp and the total quantity of light are practically the same in both tests. The area of a photometric curve is meaningless. The reason is that the candle-power at the horizontal represents the intensity of light throughout a larger zone than the candle-power at the vertical. The zones throughout which the light is distributed might be compared to the zones on the surface of the earth. Consider for a moment a hollow transparent sphere with a light-source at the center and zones similar to those on the earth laid out on the surface of the sphere. Take two zones of equal width, one near the equator and one near the poles. It is apparent at once that the zone near the equator is of greater area than that near the poles, and since the photometric curve shows the candle-power in a vertical plane, candle-power values near the horizontal represent more light than equal values near the vertical. It follows that an average of candle-power values taken at equal intervals on the curve is not the average candle-power of the light-source. To obtain this true average or mean value, the curve can be plotted on what is known as the Rousseau diagram. This is illustrated in Fig. 6. The angles are laid off at distances proportional to the areas of corresponding zones on a sphere. The curve may be plotted on this diagram and readings then taken at equal intervals. The average of these readings represents the true average or mean candle-power in the upper or lower hemisphere, or both, as the case may be.

Recently a shorter method of determining this has been introduced and is represented in Fig. 8. In each hemisphere ten lines are shown, and if candle-power readings are taken from the photometric curve at each of these ten angles, and their sum divided by ten (in

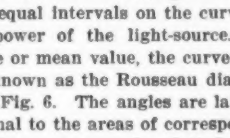


FIG. 7.—SECTION OF THE EYE.

other words, the average taken), the result will be the mean lower hemispherical candle-power or the mean upper hemispherical candle-power, as the case may be. These lines are so spaced on the diagram that they represent mean candle-powers of zones of equal area on the surface of a sphere. The angles may be laid off on a piece of transparent celluloid which can then be placed on any curve and the readings taken. An advantage of this method is that it enables one to obtain mean values in other zones by properly laying off the angles. For example, the mean candle-power in the zone from 0 to 60 deg. can be obtained by means of a piece of celluloid with ten lines properly spaced for taking ten readings in this zone. The advantage of the ten readings is that in taking the average of the readings ten is the easiest number to divide by.

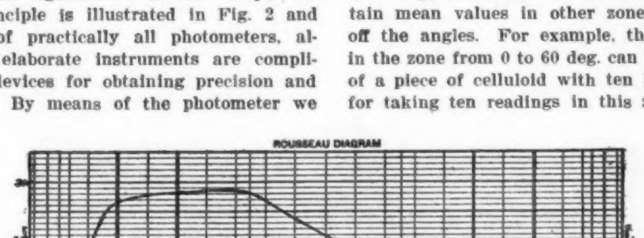


FIG. 6—CURVE OF D. C. 5½ AMP. ARC LAMP WITH OPAL INNER AND CLEAR OUTER GLOBES.

In order to give some idea of the reason why the science of illuminating engineering has grown so rapidly it is necessary to realize what immense improvement can be obtained by properly calculating the lighting system of a room. The photometric curve of a bare lamp shows that practically the same amount of light passes above the horizontal as below. The light which passes above the horizontal is useful only in illuminating the ceiling and for illuminating the lower part of the room by being reflected downward. The quantity of this light which is reflected under ordinary conditions is shown by the reflecting power of various colors. For instance, according to Bell,* ordinary white foolscap paper reflects about 70 per cent of the light striking it; orange paper reflects about 50 per cent; yellow paper reflects 40 per cent; pink paper 36 per cent; light blue 25 per cent; emerald green 18 per cent; bluish green 12 per cent; ultra-

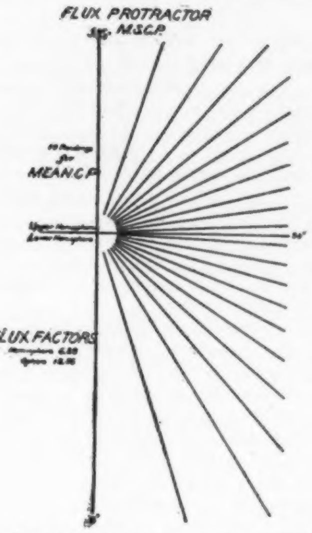


FIG. 8.—PROTRACTOR FOR OBTAINING MEAN CANDLE-POWER READINGS.

marine blue only about 4 per cent. In addition to this, when it is considered that the light rays which pass upward are ordinarily reflected two or three times before reaching the lower part of the room, causing this coefficient of reflection to enter as the second or third power, it becomes evident that the light which passes upward is very largely wasted. Recent tests† on the effect of light and dark walls, ceiling and floor show that under conditions by no means extreme either way, a difference of about 4½ to 1 can be obtained in the illumination resulting from the same lamp. In addition, when the efficiency of incandescent lamps is considered, we have the choice between carbon filament lamps in ordinary use, consuming 3.5 watts per candle, and tungsten lamps, recently introduced, which consume 1¼ watts per candle. We can, therefore, obtain a difference of 13 to 1 in the cost of securing illumination by simply varying conditions which might appear trivial to one who is not familiar with the problem. This is a remarkable state of affairs, and is without a parallel in other branches of engineering.

Up to about ten years ago practically no attempt was made in designing a lighting system, to obtain uniform illumination of any desired intensity. In electric lighting certain rules as to watts per square foot or watts per cubic foot were applied indiscriminately, paying little attention to the color of the walls, to the character of the room, the position of the lights or the absorption and distribution of light by the globes and reflectors used. After the wattage had been determined the lights were spaced largely by guesswork or with the idea of obtaining the best appearance with regard to the details which the architect wished to bring out. The first method of calculating illumination was called the point-by-point method, and consisted in assuming a certain lighting system, then finding the illumination at typical points in the room by means of the formula stated in the first part of this paper. Then if the lighting system was not good as shown by these calculations, it was changed and the calculations repeated. This was a rather laborious procedure, but the few men who used such calculations soon became experienced enough to design a lighting system with little actual figuring, and they used the point-by-point method largely for checking.

Recently, however, a much shorter method of calculation called the flux method has been introduced. Its development is largely due to the work of Messrs. Cravath and Lansingh.‡ By this method the flux or quantity of light emitted from the light-source in useful directions is used as a basis rather than the candle-power or light intensity in any direction. With small light-sources the lumen or unit of quantity of light is the flux of light emitted in unit solid angle by a light having an intensity of one candle-power in all directions. It so happens that this quantity of light di-

* Standard Handbook for Electrical Engineers (McGraw Pub. Co.), p. 745.

† "Some Experiments on Reflection from Ceiling, Walls, and Floor," V. R. Lansingh and T. W. Rolph, in the Transactions of the Illuminating Engineering Society, vol. iii, p. 584, October, 1908.

‡ "The Calculation of Illumination by the Flux of Light Method," J. R. Cravath and V. R. Lansingh, Transactions of the Illuminating Engineering Society, vol. iii, p. 518, October, 1908.

vided by the area of the surface which it strikes gives the average foot-candle intensity of illumination on this surface. This can be briefly shown as follows: Consider a sphere of radius r with a light-source of average candle-power P.

From the law of inverse squares—

Average foot-candles on the surface of the sphere $= \frac{P}{r^2}$. The area, A, of the sphere is $4\pi r^2$; hence $r^2 = \frac{A}{4\pi}$.

There are 4π unit solid angles in any sphere; hence the lumens generated $= 4\pi P$.

$$P = \frac{\text{Lumens generated}}{4\pi}$$

$$\therefore \text{average foot-candles} = \frac{\text{lumens generated} \times 4\pi}{4\pi \times A}$$

$$= \frac{\text{Lumens}}{\text{Area}}$$

This applies for a plane or any other surface as well as a sphere, so that the average foot-candle intensity on any surface may be found by dividing the flux striking that surface by the area of the surface. This is a very convenient fact and enables us to obtain the average foot-candle intensity in a room by simply knowing the total number of effective lumens and the area of the room. By effective lumens is meant the total quantity of light striking the plane of illumination or, in other words, the total light generated minus that absorbed by the ceiling, walls, floor, and lighting accessories. The total number of effective lumens must be based upon some estimates as to what proportion of the light is effective, but we can work within a small limit of error when we know the photometric curve of the light unit and the conditions of the ceiling and walls. For example, with light ceiling and dark walls and prismatic intensive reflectors we know that the effective light is the equivalent of the light emitted from the light unit, up to about 75 deg. from the vertical. We can find from the photometric curve by the method previously explained the number of lumens produced by the light-source in this zone. The total lumens necessary is the product of the intensity of illumination desired and the area of the room. Knowing the lumens necessary and the effective lumens from each light-source, it is an easy matter to determine the number of light-sources required. These light-sources must then be placed in such a way that the illumination will be uniform, but this placement is not difficult for one who is familiar with photometric curves.

A short way of applying this method of calculation consists in using certain constants, which have been determined by illumination tests. These constants show the lumens per watt or foot-candles per watt per square foot obtained under various conditions, such as different colors of the walls and ceilings, different kinds of reflectors and globes, and different kinds of lamps.

The formula for using these constants is as follows:

$$\text{Total watts necessary} = \frac{\text{foot-candles desired} \times \text{area of room}}{\text{lumens per watt}}$$

The constants given below apply for a medium-sized or large room with light ceiling and lamps 8 to 15 feet above the plane of illumination.

Lamps	Equipment	Walls	Constant lumen per watt
Tungsten at 1.25 w.p.c.	Clear prismatic reflectors..........	Light	5.0
Tungsten at 1.25 w.p.c.	Clear prismatic reflectors..........	Dark	4.0
Tungsten at 1.25 w.p.c.	Enam. or etched prismatic reflectors	Light	4.3
Tungsten at 1.25 w.p.c.	Enam. or etched prismatic reflectors	Dark	3.4
Gem at 2.5 w.p.c.	Clear prismatic reflectors..........	Light	2.2
Gem at 2.5 w.p.c.	Clear prismatic reflectors..........	Dark	1.8
Carbon at 3.1 w.p.c.	Clear prismatic reflectors..........	Light	1.8
Carbon at 3.1 w.p.c.	Clear prismatic reflectors..........	Dark	1.5
Carbon at 3.1 w.p.c.	Lamps bare	Light	.60 to 1.3
Carbon at 3.1 w.p.c.	Lamps bare	Dark	.5 to .8
Carbon at 3.1 w.p.c.	Opal dome or cone reflectors	Light	1.7
Carbon at 3.1 w.p.c.	Opal dome or cone reflectors	Dark	1.4
5 amp. D.C. Arc	Clear inner and opal outer globes..	......	2.0

This method may be applied equally well for gas calculations in which case the formula would read:

$$\text{Cubic feet of gas per hour necessary} = \frac{\text{foot-candles desired} \times \text{area of room}}{\text{constant}}$$

The constant would be lumens per cubic feet of gas per hour necessary to produce one foot-candle. Very few reliable illumination tests have been made on gas equipment, however, so that the method cannot be widely applied. Mr. Norman Macbeth* has determined the lumens per cubic foot of gas per hour for a large room with light ceiling, dark walls and inverted gas burners with prismatic reflectors. The value is 104. After the total watts or total cubic feet of gas per hour necessary have been determined they must be divided up among the number of units desired, spaced in the proper manner. This method of calculating illumination promises to prove exceedingly valuable. At the present time we lack constants for many conditions commonly met with. As fast as reliable illumination tests are made, however, constants can be added to the list and the scope of the table increased.

A paper of this kind is not complete without some consideration of various methods of equipping light-sources. Such equipment may be divided into three general classes; globes, reflectors, and shades. Globes are inclosing or partly inclosing accessories, which may or may not have a favorable effect upon the distribution of light obtained from the light-source. Reflectors are accessories which change the distribution of light by means of reflection. Shades, as their name implies, are accessories which have as an object the decreasing of the light intensity or the addition of some decorative effect desired. As a rule they do not have a favorable effect upon the distribution of light.

There are several kinds of inclosing globes in ordinary use. The principal ones of these are prismatic, opal, ground glass, and art glass. Neglecting the question of appearance, prismatic globes are superior to opal or ground glass, since their absorption is considerably less and they are designed to direct a large part of the light rays into a useful direction. Prismatic globes such as holophane, when designed and used correctly, absorb from 10 to 14 per cent of the light. Tests on incorrectly designed prismatic globes have shown an absorption as high as 34 per cent. Opal absorbs from 25 to 60 per cent, depending upon the density. In order to obtain a desirable appearance opal globes should never be used unless they are sufficiently dense to hide the outline of the lamp filament. Ground glass absorbs from 20 to 40 per cent. Art glass has a very high absorption, but is valuable in obtaining decorative effects.

There are a large variety of reflectors on the market, among which the most common are prismatic, opal, mirror, metallic, and coated. Reflection from any surface is of two kinds—regular or specular reflection and diffuse reflection. When a ray of light is regularly reflected the angle of incidence is equal to the angle of reflection. With diffuse reflection the light striking the surface is broken up into a large number of rays which leave the surface in all directions. Most surfaces give both regular and diffuse reflection with one kind predominant. Each kind of reflection has its advantage for certain cases. Certain types of distribution of light can be obtained only with surfaces giving specular reflection. On the other hand, specular reflection with filament lamps often produces bright streaks or striations in the illumination of a surface. These can be eliminated by using frosted lamps, and in some cases by using bowl-frosted lamps. Completely frosted lamps are usually undesirable because frosting reduces the life of the lamp about 50 per cent. Where the reflection is diffuse, striations are not usually met with.

With prismatic reflectors, it is impossible to direct all the light rays downward. This quality is not objectionable, however, for general illumination, since it is desirable to have a certain amount of the light pass upward in order that the ceiling and upper walls may not be in darkness. Prismatic reflection is specular reflection; it is, therefore, possible to direct a light ray in any direction, and a prismatic reflector can be constructed to give practically any desired distribution of light. Mirror reflectors differ from prismatic reflectors in that they allow no light to pass upward. Reflection here is specular also, and therefore such reflectors can be designed to give nearly any desired distribution. The fact that they allow no light to pass upward makes them objectionable for general illumination, although a system of indirect illumination* recently introduced makes use of mirror reflectors. Opal reflectors are as a rule fairly efficient, but they differ from prismatic and mirror reflectors in that the reflection obtained is diffuse and not specular. This means that only photometric curves of a general rounded shape can be obtained. Opal reflectors having a depolished interior surface have recently been introduced. The depolished surface practically eliminates striations in the illumination obtained. These reflectors present an attractive appearance and have a good efficiency when used with clear lamps. Tests with bowl-frosted lamps are not yet available. Metal reflectors can be obtained in a large variety of styles and sizes. Their principal use is for factory lighting, although iron reflectors with a coating of white enamel are used considerably for street lighting. Reflectors for factory lighting are usually of aluminium, brass or steel. With such reflectors a diffuse reflection is highly desirable. This is usually obtained by a depolished aluminium surface or by aluminium paint.

Illuminating engineering covers so broad a field that this paper can do no more than touch a few of the essential features. Although the work of the illuminating engineer is comparatively new, it has proved so valuable that the development of the science and art has been exceedingly rapid. The literature on the subject has already assumed large proportions, and each year sees additions of great value. The growth of the Illuminating Engineering Society is an evidence of the prevailing interest in the subject. Formed three years ago, it has grown faster than any other engineering society in existence and now numbers over 1,000 members. The papers presented before its meetings contain some of the most valuable data available on the subject. There is much work yet to be done before illuminating engineering is fully recognized as an important factor by all parties concerned, but at the present rate of advancement this complete recognition is not far off.

* "The Illumination of an Auction Room." Norman Macbeth, The Illuminating Engineer, November, 1908, p. 488.

* "Indirect Illumination." Augustus D. Curtis and A. J. Morgan. Transactions of Illuminating Engineering Society, vol. iii, p. 740, December, 1908.

PROCESSES FOR THE FIXATION OF ATMOSPHERIC NITROGEN.

THE method used by Birkeland and Eyde depends upon the well-known fact that an electric arc may be broadened out into a fan shape under the influence of a magnetic field. Through the arc thus formed air is driven. Since, however, only a small portion is raised to the temperature necessary for the reaction, while the greatest part serves for cooling, the gases escaping from the Birkeland furnace at a temperature of from 600 deg. C. to 700 deg. C. do not contain more than from 1 per cent to 2 per cent of nitric oxide. For further cooling, the gases are led under boilers or through a distilling apparatus, and, finally, at a temperature of about 50 deg. into an oxidation chamber, where further oxygen is taken up, forming nitrogen dioxide, which in turn is absorbed by water, and thus converted into nitric acid.

To facilitate shipment, not a pure calcium product, but a basic nitrate less hygroscopic was obtained. By a new process (German patent 206,949) the nitrous gases are absorbed by calcium cyanamide, forming a mixture of nitrate of ammonia and nitrate of calcium. When this solution is tested with sulphate of ammonia (Norwegian patent 18,029 of Birkeland) calcium sulphate is deposited, leaving a solution of an ammonium product. By testing this again with sulphuric acid, and distilling, nitric acid is given off, and sulphate of ammonia remains. By this means, therefore, concentrated nitric acid is also obtained from the nitrous gases. The furnaces, used in the Norwegian plants (the first at Notodden) for the production of nitric acid from the air, work with 500 to 700 kilowatts at a pressure of 5,000 volts. The coefficient of reduction of these furnaces is 0.7 to 0.75.

The method of Schönherr (Badische Anilin- und Soda-Fabrik) is said to be much more economical in the use of electric energy. In this process a perpendicular tube is employed having at the lower end an electrode, between which and the walls of the tube or an upper electrode a long arc is maintained. The air rushes whirling through the tube, filling it throughout its length, which may be several meters, with a steadily burning arc. There are now three furnaces, each employing about 600 horse-power, and using an arc about 5 meters long. Single-phase current is used at high pressure.

Recently Birkeland has lengthened his furnace and considerably increased the distance between the electrodes. By means of the magnetic field a long arc is produced which takes the shape of a screw and rotates in the furnace; by this means the air, which enters in the direction of the arc, is set in violent motion (American patent 906,682, December 15th, 1908).

Mention should also be made of the method of Haber and König (French patent 392,670), which may be regarded as a great step in the development of the processes just mentioned. Here the mixture of nitrogen and oxygen is led under a low pressure into the narrow tube in which the flaming arc burns, the tube being well cooled on the outside. By this means, it is stated, gaseous mixtures are obtained from the air which contain from 9½ per cent to 10½ per cent of nitrous oxide, whereas in the older Birkeland-Eyde furnace only 1 per cent was obtained.

In a paper read at the recent International Congress of Applied Chemistry Mr. Bagley directed attention to the production of nitric acid and nitrate of ammonia direct from ammonia gas. A plant is working successfully in connection with a battery of coke ovens in Germany. Ammonia gas mixed with air is forced rapidly through a plug of platinum. Every seventeen parts by weight of ammonia produces sixty-three parts by weight of nitric acid of 36 deg. Bé. Nitrate of ammonia is also produced by neutralizing the nitric acid with a further supply of ammonia obtained from crude gas liquor. By a modification of the Mond process ammonia is also obtained from the gasification of peat.—Nature.

Metallic chromium, states the Brass World, is now a commercial article, and can readily be obtained with a high degree of purity and at a reasonable price. As far as is known, it has not yet become a constituent of the non-ferrous alloys, although it has long been used in making very hard and tough steels.

LIGHTNING AND THE AIRSHIP.

THE DANGERS OF ATMOSPHERIC ELECTRICITY IN AERONAUTICS.

BY L. ZEHNDER.

AERONAUTS have a well-founded dread of thunderstorms, for a small spark discharge between the balloon and a cloud, or between two parts of the balloon, may ignite the combustible and sometimes explosive mixture of gas and air with which the bag is, in practice, filled. The danger would not exist if the balloon were filled with incombustible gas, but the only incombustible gas which is light enough when cold to be used for this purpose is helium, the rarity and cost of which are quite prohibitive. The earliest balloons were filled with hot air, and the exhaust gases of a gasoline motor, which are both incombustible and hot, might conceivably be used to keep the bag filled and the balloon afloat, but the lifting power of these gases is very much smaller than that of hydrogen, so that this solution of the problem appears impracticable, at least for dirigible airships. Furthermore, though the employment of incombustible gas would eliminate all danger of explosion, it would not prevent the disruption of the gas bag by atmospheric electrical discharges.

Hence balloons will continue to be filled with illuminating gas or hydrogen, and some other means of averting the danger must be sought. In thunder storms Gerdien has observed a fall of potential of 10,000 volts in one meter of difference of elevation. The value of the potential gradient, moreover, is exceedingly variable and its direction is often suddenly reversed. The rapidity of these fluctuations is a special source of peril. A balloon possessing an electrical conductivity and a dielectric constant equal to those of the surrounding air would be exposed to very little danger of injury by atmospheric discharges, unless it should happen to cross the path of a lightning flash, but the electrical properties of balloons are very different from those of the air in which they float.

An ordinary motorless balloon which contains no large metal parts is, while afloat, exposed to no electrical danger whatever in clear, fine weather, although the atmosphere exhibits a high potential gradient even at such times. In landing, however, especially when the drag rope touches the ground, and still more when the bag is suddenly collapsed by pulling the rip cord, dangerous sparks may be produced.

Volkmann has investigated the conditions in which the gas of a balloon can be ignited by electrical discharges. He finds that such ignition cannot be caused by discharges from poor conductors, like the gas bag, netting and ropes, when these are dry or even moderately damp, but that these parts may become sources of danger when they are very wet with rain. Metal parts, if of sufficient electrical capacity, are more dangerous. Volkmann found that the gas could be ignited by discharges from a piece of metal as big as the palm of the hand, or a wet spot of the same size in the gas bag. The most dangerous parts of a balloon are the metal parts of the valve. A spark, obviously, can cause ignition only in the presence of an inflammable substance. Hence, if the valve is tight, the most powerful discharges between it and the surrounding air are quite harmless, and discharges which are effected between the valve and other conducting parts of the gas bag, and which pass through the confined gas, are equally devoid of danger so long as the bag does not contain air enough to form an inflammable mixture with the gas. But an internal discharge may cause an explosion of the balloon if sufficient air has leaked in through the envelope, and an external spark may ignite the mixture of air and gas just outside a leaky valve. It is also possible for the envelope to be perforated by a spark between the valve and a wet part of the bag near it. If this occurs, gas escapes through the perforation and mingles with the surrounding air. The mixture may be ignited by a second spark and may set fire to the envelope.

In a thunder storm all metal parts of the balloon and all wet portions of the envelope, netting, and cordage become charged by induction. The fluctuations and sudden reversals of the potential gradient may produce between these conducting parts sparks which may destroy the balloon if either of the above-described conditions for ignition is satisfied.

Sudden reversals of electrical tension are produced artificially in wireless telegraphy. Hence attempts to send wireless messages from an airship would be dangerous, in proportion to the voltage employed. There is no danger, however, in the reception of messages by an airship from a distant station, because the electrical tensions which are developed in the receiving apparatus are too small to cause ignition by sparking.

Volkmann's researches lead to the conclusion that all good conductors should be eliminated from the balloon. Even the valve and the stopcock of the filling tube should be made of non-conducting material. On the other hand, metals can be carried in the basket without fear. Even the gasoline motor of a dirigible balloon brings with it no electrical danger, although, of course, care should be taken to prevent access of inflammable gases to the ignition device. Hence, if all metals and other good conductors are excluded from the gas bag and its immediate vicinity, dirigible airships of the flexible type, such as Parseval's, are as safe as ordinary balloons.

In airships of the rigid and semi-rigid types the conditions are altogether different. In the Zeppelin airship, in particular, the combination of a number of hydrogen-filled gas bags with a great stiffening frame of aluminium, supplies every condition for easy ignition by electrical discharges. The great height of the airship (43 feet) makes possible the development of a potential difference of 65,000 volts between it and the surrounding air. In consequence of the great length (430 feet) this difference may be increased to 500,000 volts at the ends, when the airship is in an inclined position. As only 3,000 volts are required to produce sparks capable of causing ignition, the destruction of a Zeppelin airship in a thunder storm, at Echterdingen, is not surprising.

Zeppelin's rigid system of construction possesses undoubted advantages, but it involves dangers which should be eliminated or, at least, minimized. Three methods by which this end may possibly be attained suggest themselves.

In the first place, wood might be substituted for aluminium in the construction of the skeleton. The possibility of making a sufficiently light, rigid, and durable frame of wood, without metal nails or bolts, must be determined by experiment.

The writer has suggested providing the aluminium skeleton with a system of lightning protectors so arranged that all electrical discharges would take place at projecting points, placed far from the valve and other probable outlets of gas, and suitably protected against mechanical injury.

In the third place, the envelope of the balloon might be made of sheet metal, the stiffness of which would make it possible to diminish the weight of the skeleton, perhaps to an extent which would make the total weight less than that of the Zeppelin airship. A metal balloon would incur little danger from atmospheric electricity. The envelope itself would be incombustible, no discharge could take place in its interior, and the charges induced in its various parts would neutralize each other without damage or would escape harmlessly from edges and points. A balloon of polished metal might possibly be operated by hot incombustible gases, which would cool less rapidly in such an envelope than in any other, and the incombustibility of the envelope would make it possible to employ the exhaust gases of the gasoline motor for this purpose. Such a balloon would be absolutely free from danger of explosion. It could not be injured by lightning, the ignition device of the motor, or the sparks of a wireless transmitter, and it would suffer little even from the fire of the enemy, unless a shell should penetrate it, explode and shatter it into many fragments. Even in this case the parachute action of the part which remained attached to the car would probably enable the aeronaut, by jettisoning all useless weight, to reach the ground unharmed.

Aeroplanes are in little danger of injury by atmospheric electricity, even in violent thunder storms. The electrical capacities of the motor and of the aeronaut's body are too small to cause discharges dangerous to life to pass between them. If the gasoline container leaks, however, the escaping fluid might possibly be ignited by a spark caused by atmospheric electricity.—Umschau.

THE PERCEPTION OF LIGHT IN PLANTS.

By HAROLD WAGER, F.R.S.

IT is well known that various plant organs exhibit a definite response to the action of light. Free-swimming organs, such as zoospores, moved toward or away from the source of light. Orthotropic organs, such as young seedlings, stems, and roots, bend toward or away from the light, while diatropic organs, such as foliage leaves, place themselves at right angles to the direction of the light. It was shown by C. and F. Darwin in 1880 that the illumination of one part of the sensitive organ determines the movement in another part; that one part of the sensitive organ perceives the light, and that a stimulus is set up which is transmitted to another part, where the movement takes place. In ordinary foliage leaves the leaf-blade is usually the perceptive region, the movement being brought about by the petiole. It is clear that the object of these heliotropic movements is either to protect the plant from a too intense light, or to bring it into such a position that it can take the fullest advantage of the light which falls upon it. There can be no doubt that this is effected with considerable precision. But how it is that the plant is enabled to perceive that it is or is not in the right position, and the means by which the light stimulus is set up, are not yet clearly understood. In the case of free-swimming organisms, such as Chlamydomonas, Euglena, etc., it is probable that the eyespot or its equivalent is the percipient organ. The light rays absorbed by the eyespot are those which are functional in heliotropism, and these may act in some way upon the flagellum either directly or through the cytoplasm, and so bring about the necessary modifications of its movements by which the course of the organism is changed. In dia-heliotropic foliage leaves Haberlandt suggests that the epidermal cells or special modifications of their function act as ocelli or rudimentary eyes by converging the light so as to bring about a differential illumination of the cytoplasm on the basal wall of the epidermal cells, by means of which the stimulus is set up. The layer of cytoplasm lining the epidermal cells would therefore in this case be the percipient organ. The evidence in favor of this view is, however, not very satisfactory, and has been recently criticised, both on morphological and physiological grounds. As an alternative to this view, it is suggested that the chlorophyl grains are the percipient organs. It is well known that they are sensitive to light, and that in some cases they show this by definite responsive movements. The unequal illumination of the chlorophyl grains when the rays of light fall upon the leaf in a slanting direction would be sufficient to account for the generation of the stimulus, and it is possible that the optical behavior of the epidermal cells may be of importance in this respect. The rays of light which are absorbed by the chlorophyl are the only ones which appear to be functional in heliotropism, and these, by their action upon the various coloring matters contained in the chlorophyl, may set up in the cytoplasm immediately adjacent changes necessary to bring about the stimulus.—Abstract of a paper read before the Winnipeg Meeting of the British Association for the Advancement of Science.

Large-scale experiments on the underflow or subsurface flow of water through saturated sand or gravel are being made by the United States Reclamation Service in the Arkansas Valley, western Kansas. After a search and tests to find a supposedly heavy underflow a row of wells was sunk across a valley near Deerfield, Kan., and pumps were erected there. A press bulletin issued by the Service states that the wells and pumps lowered the water plane 19 feet or 20 feet below the river level; also that during the latter part of 1908 the wells began to weaken materially, the total amount of water removed being 10,000 acre feet; that is to say, enough to cover 1,000 acres 10 feet in depth, or sufficient to irrigate, say, 4,000 acres. By April, 1909, the gravels had become filled again on the north side of the river, but in the valley on the south side the "underflow" was not sufficient to restore the amount pumped during the preceding year. During 1909 the pumps lowered the underflow much more rapidly than in 1908. Part of the wells, or groups of wells, are allowed to stand idle in order to recuperate while the others are being pumped. It is hoped that by this system as much water can be obtained in 1909 as in 1908. The experience, however, shows that the so-called underflow, even where best developed, is not very reliable.

A new astronomical compass, which will be of great use to explorers and others, and by which the time may be told without any elaborate calculations, has been exhibited by the British Astronomical Association. The little instrument has already been adopted in India for military purposes.

THE TUNNEL UNDER THE DETROIT RIVER.

A WONDERFUL ENGINEERING ACHIEVEMENT.

BY NORMAN B. BEASLEY.

A TUNNEL, the feature of which was that its construction marked an entire departure from the methods used in previous tunnel work, is now being built by the Michigan Central Railroad under the Detroit River at Detroit. Ten separate tubes, 64 feet 8 inches in length, were sunk at different periods. There were eyes on either end of these tubes that corresponded with holes on the other sections, and through these heavy bolts were drawn and tightened by divers. Following this a rubber shield was fitted between the sections, for the purpose of shutting out the water.

It means something to undertake such a task. It means vastly more to carry it to a successful ending. First it was absolutely necessary that these tubes be sunk exactly right, a fraction of an inch either way making a world of difference; then to bring to a successful ending the sinking of this double-barreled tunnel of steel and concrete in the bed of a river through which passes the greatest tonnage of any waterway in the world without interfering with commerce. The experience gained from the shield-driven tunnels, such as are at Port Huron, under the St. Clair River, and at New York, under the East and North rivers, was of no assistance except on those portions marking the approaches on either side of the river.

These different tubes were madé at a shipyard several miles north of Detroit, and then floated down to the scene of operations. When the dredges had excavated sufficiently, so that a minimum depth of 25 feet of water would flow over the top of the tube when it was in position, the tube was carefully lowered into position. It was necessary that allowances be made for any and all contingencies that might arise. The different currents in the river, their velocity, and even the air currents, played a part. The sinking of the first tube was perhaps the most crucial period in the whole undertaking. Though the tubes seemed altogether satisfactory above water, it was not known how they would behave when immersed, and it was with the keenest anxiety that engineers peered over the sides of their boats until the word had come up from below that everything was satisfactory.

When the tunnel was started, the United States government notified the engineers that a minimum depth of 25 feet of water should be left above the tubes. Not only was this instruction followed out, but near the Canadian shore, where most of the vessels pass, there is a depth of 50 feet of water above the tubes, and in some parts 75 feet of water passes above them. In some cases the engineers went five feet or more below this, so as to make sure of the foundation.

The total distance where excavating was necessary is about two and one-half miles. Of this, one-half mile is through the river, where a course was dug and tubes, after being sunk, were imbedded in concrete. Merely to show how well the tunnel is protected from outside influences, it might be mentioned that the tubes are surrounded by four feet of concrete, and that from one end to the other there is a reinforced lining of 20 inches of concrete. It is thought that this will make the tunnel practically indestructible.

So far as appearances are concerned, the tunnel on the Detroit side of the river is practically complete, but on the Canadian side considerable work remains to be done. It is three years since the first tube was sunk in the river, and if all goes well this unique engineering feat, which cost in the neighborhood of $10,000,000, will be finished in the spring of 1910.

After considerable deliberation, what seemed to be the most unfeasible of all the proposed undertakings was adopted, and the engineers made known their intention of damming the Detroit River between Stony and Bois Blanc islands, and then unhampered by the elements blast a ship channel through the rock formations in the bed of the river.

After a few preliminaries the present contractors on the undertaking were awarded the contract, which stipulated the work should be completed in 1911. A cofferdam has now been constructed, and laborers have succeeded in gouging a course nearly 3,000 feet in length.

In forcing the rock, pneumatic drills are first used in boring a series of holes, and when sufficient territory has been covered, dynamite is placed in the apertures and then discharged. Huge masses of rock are thus torn loose from their resting place of ages, and a moment later one of the 70-ton shovels moves forward, shoves its nose into the crumbled mass, brings out a ton or more of rock, and dumps it into a skip conveniently located nearby. When filled the skip soars upward and glides along a heavy cable to a point above a mountain of rock, where it discharges its load. This process is repeated on an average of every three minutes for sixteen out of twenty-four hours for 213 days in the year. With these data a little calculating will show that now a train of forty-ton freight cars would extend one hundred and forty miles in length in carrying the present mountain of rock piled up.

The first quarrying was done at the crest of the rock, which formed an impassable barrier, and over which there flowed a depth of but three or four feet of water in spots. This necessitated some twenty feet of blasting and excavating. From this point the rock sloped gradually until at the point where the excavating ceased, there was a fair depth of water. Unlike the old method, it is thus possible to leave the floor of the river as smooth as a table, thereby eliminating the danger of grounding or accidents.

A VIEW OF THE CUT, SHOWING THE "MOUNTAIN" OF ROCK IN THE BACKGROUND, THE STEAM SHOVEL AT WORK, AND THE DIFFERENT DERRICKS.

THE TUNNEL UNDER THE DETROIT RIVER.

THE EIGHTH SATELLITE OF JUPITER.

In 1610 the first four satellites of Jupiter were discovered by Simon Marius and, shortly afterward, by Galileo. Nearly three centuries later, four additional satellites were discovered: the fifth by Barnard in 1892, the sixth and seventh by Perrine in 1904 and 1905, and the eighth by Cowell and Crommelin, of the Greenwich observatory, in January, 1908. At first it appeared uncertain whether the eighth satellite was really a satellite of Jupiter or an independent planet, and observations extended over three months were required to settle this question. The satellite is so faint that it can be observed only by photography, with a long exposure and in a perfectly dark sky. Hence no observations of the eighth satellite can be made while Jupiter is in the angular vicinity of the sun, as it was from April to October, 1908. The satellite was, however, photographed again in January, 1909, and was found to occupy a position which agreed very closely with the calculations of Cowell and Crommelin. Its orbit is very eccentric and is inclined 150 deg. to the orbit of Jupiter. Its least distance from Jupiter is 9 1/3 million miles, its greatest distance (which it will attain in December, 1909) is 20 million miles. Of all the known satellites of Jupiter it is the most distant from the planet. Expressed in terms of the planet's radius, the maximum distances of the four "old" satellites range from 5.9 to 26.5, that of the fifth is only 2.5, those of the sixth and seventh are 160 and 167, and that of the eighth is 440. The period of revolution of the eighth satellite is about 2 years and 2 months, while that of the fifth is only 11 hours, 57 minutes, and 22.6 seconds. The newly-discovered satellite has a retrograde motion, or moves from east to west, in opposition to the motions of most of the bodies of the solar system. The same peculiarity is exhibited by the four satellites of Uranus, the satellite of Neptune and the ninth and outermost satellite of Saturn, which was discovered by Pickering in 1898. Because of the great distance of the eighth satellite from Jupiter, its motion must be greatly disturbed by the attraction of the sun. From the earth the satellite appears as a star of the 17th magnitude, and even from Jupiter it would appear as a star of the 9th magnitude, invisible to the naked eye. Its absolute diameter is probably about 35 miles.—Prometheus.

TELEPHONES FOR PEKING.

AN ELECTRICAL INNOVATION IN AN ANCIENT CITY.

The acquiescence of the Chinese government in Japan's proposed standardization of the Autung-Mukden Railroad to enter the trans-Siberian system indicates a point of departure in the diplomatic methods of China. Apparently the traditional procedure of the government—that of refusing a concession to one power to present it to another for protection against the first applicant—has been superseded by a tendency to give courteous consideration and a sane avoidance of prejudicial decisions that is manifesting itself gradually in the working of the Imperial Boards at Peking.

The Imperial Boards of to-day are the creations of the Regent, Prince Ch'un. They are perhaps the most remarkable body of men ever summoned out of a body politic to lift a medieval nation of 400,000,000 people out of an all-enveloping intellectual fog of mingled necromancy, superstition, ignorance, and fanaticism, and in one generation to place them as a whole upon an equal footing with modern thought. This without a revolution and without even a popular demand for an evolution.

Of all the Imperial Boards of Peking, the most active and the most heavily burdened with responsibility by the Prince Regent, and at the same time most interesting to America from a commercial point of view, is the Board of Posts and Communications. This is the body which came into conflict with the Japanese in the matter of the gage of the Autung-Mukden road, whose acquiescence to the Japanese demand for the standardizing of the road, delivered not only promptly but courteously, surprised and gratified the Japanese legation at Peking. The acquiescence cleared the war cloud that seemed to be rising on the horizon of the Yellow Sea, and to threaten the process of evolution with disaster.

This Board maintains a close supervision of all railroads, posts, navigation, telegraphs, and telephones not operated under foreign concessions. Its work is just coming into general notice, for its maturing plans are being pushed to a materialization.

The first of these was the contract for a $150,000 telephone plant for Peking itself.

The multifold activities of the Board have perhaps as much to do with the innovation as anything else.

TELEPHONE EXCHANGE IN SAN FRANCISCO'S CHINATOWN.

THE PRESENT EXCHANGE OF SAN FRANCISCO'S CHINATOWN.

THE TELEPHONE EXCHANGE OF TOKYO, JAPAN.

TELEPHONES FOR PEKING.

For the closer the supervision grew, the greater the need for a means of instant communication became. Having decided that the telephone was absolutely essential to the progress of China, the Board ignored the possibilities of a conflict between the old and new China, and invited bids from the principal telephone manufacturers of the world, some of whom are unknown in this country, but whose agents have been active in the Orient for years and were thoroughly intrenched.

The strength of the faith of the Board in the future of the new China was shown by the specifications, which called for two complete central office telephone equipments for the capital city of Peking, each capable of handling 6,500 subscribers, with 2,100 telephones to be installed at the outset. This is not an unusually large telephone plant, but as an innovation in the lives of the superstitious citizens of the city of Peking, it cannot be overestimated. Only a comparatively few years ago, it will be recollected, the Peking Boxers devoutly believed their cotton shirts were proof against the bullets of the allies. If a traction company of a metropolis of the United States suddenly substituted aeroplanes for rolling stock, and invited patrons to try their luck at flying, the innovation might be more disastrous, but no more startling, and would create no more consternation than that which will be aroused when Peking is called to the 'phone by our apparatus six months hence. Curiously enough, the San Francisco Chinatown Central, which is operated by half a dozen Chinese women, assisted the American bid to an extent perhaps not fully appreciated, for it proved to Secretary Wu of the Imperial Board and his associates who visited that exchange that American apparatus was already in use among the Chinese, and was being operated by them. The sight of American telephone booths side by side with the idols in the Chinatown joss houses of San Francisco, showing that the Chinese in this country considered it no sacrilege to introduce the telephone into the presence of the gods themselves, made a deep impression. Doubtless the Commissioners speculated upon the value of returning countrymen as demonstrators of the value of the innovation, particularly if the same equipment was used.

The deep research that precedes oriental progression in an occidental direction was particularly marked in the move toward the telephone. As the first step, Wu Kuei Ling, secretary of the Board of Communications, came to the United States, visited the Chinatown Central at San Francisco in July, 1908, while bound for the International Telegraph Conference at Lisbon, and called at the Chicago office.

Mr. Pingree was detailed to accompany the party for the rest of the tour eastward, and conducted it on an inspection of the telephone systems of New York and other cities. At the conclusion of the conference at Lisbon, Mr. F. N. Dresing, foreign adviser of the Imperial Chinese Telephone Administration, who had traveled to the conference *via* Suez and visited the European telephone central stations, called in August at the Chicago office of the Western Electric Company with the specifications of two switchboards, and continued inspecting stations all the way west to the Chinatown Central, where he, too, was impressed with the familiarity of the Chinese with the American equipment.

At the end of six months, on August 4th, the Export Department of the Western Electric Company received a cablegram stating that the American apparatus had been chosen.

Most of the cable will be put underground, so that Peking will enjoy an up-to-date system equal to that of New York, Chicago, and San Francisco. Within the next few years, China will have a railroad system extending practically over the entire country, connecting Canton with Hankow, Shanghai, Peking, and Tientsin, tapping the rich valley of the Yangstaze, and extending north through the Mongolian pass to the trans-Siberian road. The roads are wide gage and well built, and prove a source of considerable income to the government. It was to this system the Japanese proposed to connect by the standardizing of the little Autung-Mukden line of 180 miles. At present its narrow gage and slow schedule is practically valueless for trade purposes; for its terminal ports at Dalny and Port Arthur are isolated.

THE ORIGIN OF WORLDS.

RECENT THEORIES OF STELLAR EVOLUTION.

BY G. MILLOCHAU, OF THE PARIS OBSERVATORY.

In all times human beings have been interested in seeking an explanation of the origin of the universe, the creation of the earth and the heavenly bodies which give it light. The first systems of cosmogony, that of Genesis for example, are simple, rudimentary, unscientific, and filled with a *naïve* poetry. All of them were designed to serve as the bases of religions, and they attribute the causes of all phenomena to the direct intervention of Deity. The Greek and Latin philosophers attempted systems in which a little science was ingrafted on religious traditions, but Kant was the first to invent a theory of the formation of the universe which rests on a solid foundation and is the basis of modern systems. In 1755 Kant wrote his "General Natural History and Theory of the Heavens." In this remarkable work the author, assuming with Lucretius, Epicurus and Democritus, that in the beginning was chaos, consisting of the fragments of all the heavenly bodies, imagines for the explanation of the origin of the solar system that a vast nebula composed of fine particles assumed a rotary motion. This motion, gradually becoming swifter, caused the formation of rings which broke and formed planetary nebulæ which behaved like their parent, and thus planets and satellites were produced. Kant, with the little scientific knowledge of his period, often exceeded in his conclusions the logical result of then known laws. For example, in his theory of the formation of Saturn's ring, which he attributes to the separation of part of the vaporous atmosphere of that planet, he pictured the actual constitution of this ring as it is shown to us by recent investigation, that is to say, a series of concentric rings of particles, in which each particle moves as an independent satellite. Forty years later, Laplace, in ignorance of the work of Kant, devised his theory of cosmogony.

The hypothesis of Laplace supposes a primordial mass of gas, the condensation of which formed successive concentric rings as in Kant's theory. Laplace did not reach this conclusion at once. At first he supposed that the solar system originated in a stellar nebula which threw off rings, from which the planets were formed, and from this he advanced to the idea of a universal original nebula. The scope of this article does not allow us to develop these theories in detail, nor to analyze those of Herschel (1811), Trowbridge (1864), Roche (1873), and others, the more so as the conclusions of these authors depend greatly upon auxiliary hypotheses, introduced in the course of calculation. In 1884 Faye modified Laplace's hypothesis by supposing that cyclones in the primordial mass produced spiral streams which were afterward converted into rings.

All these theories show us a planet formed by condensation of a circular ring into a single mass. If this has actually occurred we should find among the nebulæ various stages of these transformations. The recent advance of astronomical photography has rapidly increased our knowledge of the structure of nebulæ and star clusters. None of these objects exhibits a perfectly circular form. In all nebulæ the spiral is more or less indicated and this formation has certainly produced the condensation which produced stars. The star clusters have a similar formation. We possess also much spectroscopic information of double and multiple stars, from which we can infer that not all stellar systems are constructed on the model of our solar system. On the contrary, our system, with a single central sun surrounded by planets, is rather exceptional. Most of the systems are double, having two suns of almost equal masses, although often of very dissimilar spectra, which indicates that they are at different stages of evolution. In the meanwhile the development of thermodynamics has given us new views of the constitution of matter.

Matter is capable of assuming various states, of which the principal are the solid, liquid, and gaseous. To each state assumed by a certain mass of matter corresponds a certain quantity of energy, which is connected with that mass and is called potential energy. When this matter is transformed and gives out part of its potential energy, either in the form of radiation or by doing mechanical work, the energy thus liberated modifies neighboring portions of matter. Thus the energy contained in matter becomes gradually degraded and less available, and a system limited in space tends toward a condition of equilibrium, in which the energy which it contains is not able to undergo any further modification or to perform any work. Let us suppose two bodies in presence of each other. The body which possesses the greater energy, that is to say, the hotter body, is constantly giving up energy to the cooler body, which thus becomes heated, and the effect of the mutual radiation is to bring both bodies to the same temperature. After this is attained no further exchange of energy can take place between the two bodies which are in thermal equilibrium with each other. Let us assume a body at the lowest imaginable temperature. If we communicate energy to it it becomes heated. At first its appearance remains unchanged, but it expands, then it changes its state, and its structure is altered. It becomes a liquid, then a gas, the density of which continues to decrease with increase of temperature if the pressure is not changed. At a still higher temperature, it is dissociated or decomposed into other substances having other properties. At a still higher temperature these new bodies in turn become dissociated, and the process continues probably until the matter reaches the simplest state that it can assume and which we may suppose to be that of the gaseous nebulæ. If the mass of gas thus obtained is allowed to cool by radiation it passes in an inverse order through all the phases above described until it reaches its original condition.

Spectrum analysis reveals the existence in the gaseous nebulæ of very few of the chemical elements—hydrogen, helium, and a third gas not yet discovered on the earth. The matter which composes these nebulæ is, therefore, at the highest point of dissociation, or nearly so, and its temperature must be very high. Its potential energy is consequently very great. This energy is dissipated gradually by radiation, the temperature falls, the gas contracts, and when the point of dissociation is attained the first chemical reactions take place. The energy liberated in these reactions again heats the mass, maintains the radiation and retards the process of cooling. To this energy is added that which is furnished by the contraction of the mass.

Changes of physical state do not occur readily in the absence of particles in the final state, or, so to speak, germs of that state. For example, water may remain liquid below the freezing point, and phosphorus may remain liquid very much below its melting point. It must be the same in the nebula; the changes of state and the reactions no doubt take place around nuclei produced by the shattering of dead worlds and coming from the depths of space.

We can even find here an explanation of the formation of double stars. It is only necessary to suppose that one of these stars, the cooler one, has been formed around a large nucleus, consisting of an extinct but still entire sun which has become entangled in the nebula at an epoch when the latter already possessed a central nucleus of condensation of the same order of magnitude.

The sudden appearance of temporary stars is an example of this phenomenon. The most celebrated of these stars is that observed by Tycho Brahé, which appeared suddenly in the constellation of Cassiopeia, and the brightness of which surpassed that of Venus. Appearing in November, 1572, it gradually became less brilliant, and became invisible to the naked eye seventeen months later, in March, 1574. In 1604 a star almost equally bright appeared in Ophiuchus and remained visible about fifteen months. In 1866 a temporary star of the second magnitude appeared in Corona Borealis. This was the first temporary star to which spectrum analysis could be applied. The star showed a spectrum of dark lines, upon which was superposed a spectrum of bright lines of hydrogen and helium. It appears, then, that the apparition of a temporary star is due to an incandescent mass of hydrogen and helium suddenly enveloping an invisible star. The temporary star which appeared in Cygnus in 1876 showed a similar spectrum. In 1877 Lindsay observed that it resembled a nebula. But the most interesting of temporary stars is certainly that which suddenly appeared on February 21, 1901, in the constellation of Perseus, at a point where on the previous day no star brighter than the 12th magnitude existed. The new star, of the second magnitude on the day of its discovery, increased to the first magnitude on the following day, and then diminished in brightness, while its color changed gradually from blue to red. All the methods of modern astronomy, the most powerful telescopes and spectroscopes were employed in the study of this rare phenomenon, and very interesting results were obtained. At its first appearance, the star, to judge from its spectrum, was

surrounded by an atmosphere of hydrogen and helium in the condition of vibration characteristic of a very high temperature. Photographs taken subsequently indicated that the star became nebulous, and at the same time the nebular rays appeared in the spectrum. Around the star appeared, from time to time, nebular rings which seemed gradually to separate from the star. It was supposed that this appearance of rings was due to the illumination of the nebulous envelope by the star's intense light. All these observations taken together lead to a simple explanation of temporary stars. A dead or dying sun, nearly or quite cool, encounters in its flight through space a nebular mass. The impact causes a loss of kinetic energy and a great disengagement of heat, which raises to a high temperature the nearest portions of the nebula. At the same time these gases condense around the star, which gradually becomes heated and finally dissolves in the surrounding nebular mass. Here we see one form of the resurrection of a world.

Whether the primordial nebula originates in a formation similar to that of temporary stars or from a more violent collision between two dead or shattered stars, the mass of gas is not at first absolutely motionless. The impact which produces it gives it a rotary movement. The condensation caused by changes of state of portions of the nebula, the initial rotary motion and the attraction of gravitation determine the spiral arrangements observed in all nebulæ. The spiral afterward condenses into a nucleus, which in turn becomes a small nebula and subsequently a sun. This sun is first blue and surrounded by a vast atmosphere of hydrogen and helium. Afterward it becomes white, and metallic vapors appear in its atmosphere, then yellow, red, and finally, when completely cooled, it becomes dark and passes slowly into the planetary condition.

When the temperature of a sun has become sufficiently lowered, compound bodies, oxides, and salts begin to appear and the metallurgical operations which we commonly execute on earth are examples of the phenomena which may then take place. How is the solidification of an extinct sun brought about? By the gradual thickening of a superficial crust, as the majority of astronomers believe, or from the center (as matter is in general heavier in the solid than in the liquid state); or, finally, by a general crystallization similar to that which occurs in the case of most metals? The following facts speak in favor of the last hypothesis. Meteorites are composed chiefly of iron, alloyed with similar metals, and called meteoric iron. The spectroscope shows us this metal abounding in stars in the first stage of cooling; hence it is very probable that suns are largely composed of meteoric iron. At a temperature of about 1,200 or 1,500 deg. C. (2,192 to 2,732 deg. F.) this iron would become crystallized as a solid nucleus, which may include a cavity, and would be covered by a gangue or slag of fusible matter, as cast iron is covered in a blast furnace. At this temperature water could not exist, as it would be dissociated into hydrogen and oxygen. At a slightly lower temperature certain reactions could take place, forming chlorides, iodides, and carbides in the planetary crust, and at a still lower temperature the vapor of water would appear in the atmosphere. Below 300 deg. C (572 deg. F.) the soil of the planet would become moist and aqueous reactions would occur. All these reactions taken together suffice to explain the volcanic and geological phenomena observed on the earth.

Very little is known of the crust of the earth. The thickness of the paper wrapped around an orange of medium size is at least six times greater in proportion to the orange than the deepest of our borings is in proportion to the earth. It would be a very bold insect which would pretend to know the composition of an orange because it had perforated the paper envelope. Hence we are at liberty to make any supposition which does not contradict observed facts. Now, celestial mechanics show us the earth rigid as steel. The volcanic regions are relatively near large masses of water and the center of disturbance in earthquakes is generally about 10 miles below the surface. These facts, as well as the variation of the geothermic gradient (the rate at which the temperature increases in going downward) found in various borings, are in perfect accordance with our hypothesis, and all volcanic phenomena can be explained at least as simply by the effect of water upon anhydrous materials of deep-lying rocks, as by the existence of a central fire. This theory of the formation of planets accounts also for a fact which is very embarrassing in other theories, the differences of density of the planets. These planets and the sun may be arranged in order of increasing density as follows: Saturn 0.7, Uranus 1.07, Jupiter 1.33, the sun 1.39, Neptune 1.65, Mars 3.91, Venus 4.44, the earth 5.50, Mercury 6.45.

The order is not regular, but in general the inner planets are denser than the outer planets. In 1870 Flammarion observed that the density is a function of the time of rotation, for all planets whose rotation is known. This should be the case on our hypothesis, as a central cavity is formed by the centrifugal force in combination with the force of crystallization. Attempts have been made to explain this variation of density by the gravitation of the denser materials to the center of the system in the process of formation, but the composition of the gaseous nebula is uniform and the planetary condensations, like the central condensation, are simply portions of the original homogeneous mixture. The spectra of gaseous nebulæ prove the truth of this assertion.

If we examine the arrangement of stars on the celestial sphere we see that they are grouped around a great circle, along which lies the Milky Way. The stars are collected in a flat disk and our solar system is situated near the center of this disk. Powerful telescopes show that certain whitish spots which were formerly assumed to be nebulæ are really star clusters. Many of these clusters show a spiral arrangement, similar to that of nebulæ, and the preceding observations lead to the conclusion that our sun is a member of a spiral cluster which constitutes the Milky Way.

The study of double and multiple stars indicates that our solar system is not the model of all stellar systems, but that a great diversity exists in these. Nevertheless there is no reason for refusing to admit the existence of planets in these systems. A planet is an extinct sun and we see on the earth how life is developed on the surface of such a body. Why should not the same thing occur in the other planets of the solar system? Doubtless life is not at the same stage on all planets. Jupiter is still probably in the Silurian or the Carboniferous period, and the human race on Mars is possibly at the point of extinction. But why should the earth alone of the similar bodies be able to support life? When an extinct sun has become a planet, how does life begin on its surface—spontaneously when conditions permit, or by the reception of germs proceeding from the disruption of dead worlds and transported by meteorites?

We are able to conceive space only as infinite. Our reason refuses to admit a limit beyond which nothing exists. The portion of space which surrounds us and is perceptible to our senses contains nebulæ, worlds in process of formation, and star clusters. One of these star clusters, the Milky Way, envelopes us and we are part of it, and our nearest neighbor in this cluster is so far away that its light, though moving 186,330 miles per second, occupies four and one-half years in coming to us. The luminous rays propagated by the vibrations of the ether bring to us from immense distances the energy radiated by the heavenly bodies. Nothing forbids our believing that the reach of our vision is unlimited and that some of the rays of light which we perceive come to us from an infinite distance, or perhaps the hypothetical ether which we have imagined as a medium for luminous vibrations does not fill infinite space, and our universe is, as certain bold minds have supposed, a bubble of ether, a simple cell, floating in the infinite and beyond which all is unknown to us. When all the energy contained in the bubble shall have become degraded and equilibrium of temperature shall have been established throughout, the cell will be dead. Then probably will be realized the intuitive prevision of our great poet. Our finite universe will unite with another cell and give birth to daughter cells which will develop into new worlds.—Translated for the SCIENTIFIC AMERICAN SUPPLEMENT from La Science au XXme Siècle.

STERILIZATION OF WATER AND MILK WITH ULTRAVIOLET RAYS.

By P. Santolyne.

All the methods employed in sterilizing milk have grave defects. The addition of antiseptics is more or less injurious to the health of the consumer, heat produces undesirable chemical changes and cold is not an efficient germicide. Sterilization with the ultraviolet rays of the quartz mercury vapor lamp is free from all of these disadvantages, according to the unanimous testimony of all experimenters. The process is still in the laboratory stage and has not yet been introduced into commercial practice.

Quartz, unlike glass, transmits nearly all the violet and ultraviolet radiation which the incandescent vapor of mercury emits in so great abundance, and quartz mercury vapor lamps are extensively used for lighting shop windows. In 1906 DeMare patented a method of sterilizing water by means of a simple and compact apparatus, consisting of a low tension mercury vapor lamp, or an arc lamp with iron electrodes, inclosed in a wide tube through which the water flows. The outer tube, which is exhausted of air before the water is admitted, may be of any material. The envelope of the lamp itself is preferably made of quartz, but Jena uviol glass, which is fairly transparent to ultraviolet rays, may be substituted for the more costly quartz. Turbid water is not easily penetrated by the rays and should, therefore, be filtered before it is subjected to their action. The inventor claims that water and milk can be perfectly sterilized by this process. Applied to wine, the process has the disadvantage of causing a sudden aging and changes in color and bouquet.

In 1907 Buton-Daguerre described his experiments in sterilizing water and milk by causing the liquid to flow in a thin stratum between inclined plates of quartz in the rays of a mercury vapor lamp, and also by simply immersing in the liquid either a quartz mercury vapor lamp or an ordinary incandescent bulb of violet or blue glass.

In 1909 Courmont, Nogier, and Rochaix reported the destruction, in about one minute, of all ordinary germs and the *bacillus coli* to a distance of 12 inches from a lamp of 10 amperes and 135 volts, immersed in clear water, although ten minutes' immersion produced no ozone in oxygenated water and effected very little alteration in various dissolved substances which were purposely added.

Henri and Strodel reported to the Academy of Sciences the absolutely certain sterilization of milk with ultraviolet rays, without the production of any abnormal taste or property or any considerable elevation of temperature. Milk to which cultures of bacteria had been added was sterilized rapidly and completely, so that it was unable to produce new colonies in appropriate culture media.

The opacity of milk makes it necessary to expose it to the ultraviolet rays in thin layers. Henri and Strodel caused the milk to flow down the sides of a funnel, which was illuminated from above by a mercury vapor lamp.

The keeping qualities of butter depend very largely on the purity of the water with which it is washed. Dornic and Daire have made experiments with direct reference to this subject, using lamps of the ordinary type, of 3,000 candles and 220 volts, which exert a powerful bactericidal action even when not immersed, though it would have been preferable to immerse them completely in the liquid. The water to be sterilized flowed through a glass-lined wooden tank, 56 inches long, 24 inches wide and 28 inches deep, divided into four compartments of three glass dams of unequal heights, over which the water flowed in little cascades. Two lamps were suspended in apertures in the cover of the tank.

The water was purposely contaminated with buttermilk and was estimated, from an enumeration of colonies formed on Pétri plates of peptonized gelatine to contain 11,000 bacteria per cubic centimeter. After flowing, at the rate of 25 gallons per hour, through the sterilizing tank illuminated by one lamp run at 155 volts, the water was found to contain only 40 bacteria per cubic centimeter, but 1,500 bacteria per cubic centimeter escaped destruction with a current of 100 volts. The most effective voltage was about 155 volts.

This is not complete sterilization, but better results could have been obtained by using immersed lamps and some device for mixing the water more thoroughly and thus exposing every particle of it to the rays. The infected water was restored to a state of comparative purity, with a bacterial content low enough to place it in the class of "pure" waters, as the term is commonly used. In particular, very few of the bacteria which liquefy gelatine and which are especially unfavorable to the preservation of butter, remained in the treated water, of which only a very small quantity is left in the butter washed with it.

The butter employed in these experiments was made by the most improved methods of modern dairy practice. The cream was pasteurized at about 170 deg. F. for five minutes, instantly cooled to 61 deg. F., mixed with pure cultures of lactic acid ferments, and allowed to ferment about 18 hours. The cream was kept cool in the churn with ice made from water which had been sterilized with ultraviolet rays. Some of the butter was washed with ordinary water and some with water partially sterilized by the method described above. Both portions were made up into rolls of 6 to 11 pounds and kept under observation at the ordinary temperature of the laboratory, in June. The butter which had been washed with ordinary water showed no rancidity until the eighth day, after which it rapidly deteriorated. The butter which had been washed with the sterilized water, examined one month after making, showed only a slight superficial alteration due to the action of light and the oxygen of the air. The interior of the roll remained as fresh and sweet as butter two or three days old.—Cosmos.

A review was recently given in Stahl und Eisen of the present position of the various processes for the recovery of nitrogen from the atmosphere. The only requirement for the success of the artificial production, says the writer, is power at the lowest possible rate. An account will also be found here of the electric processes for the production of calcium cyanamide by the plan proposed by Caro and Frank of passing pure nitrogen over highly heated calcium carbide.

THE STRUCTURES OF THE STONE AGE.

HOW THE GREAT MEGALITHIC MONUMENTS WERE PROBABLY ERECTED.

The great monumental structures of the later stone age, the Neolithic or Megalithic period, were necessarily erected without the employment of any more elaborate machinery than levers and rollers made of the trunks of trees. In this period were built the tombs (dolmens) of kings and chiefs, which were roofed with huge boulders, such as the dolmen at Locmariaquer (Fig. 1) and the six which are still standing of the twelve originally erected at Fallingbostel. The largest of these weighs 20 tons. Then, also, were erected the great monolithic pillars (menhirs), such as the menhir of Cadiou in Brittany (Fig. 2), 28 feet in height, and that of Mersina (Fig. 3), which is 33 feet high and is estimated to weigh 150 tons. A still larger menhir at Locmariaquer in Morbihan, now fallen and broken into three pieces, is 80 feet long and 20 feet in circumference and weighs 200 tons.

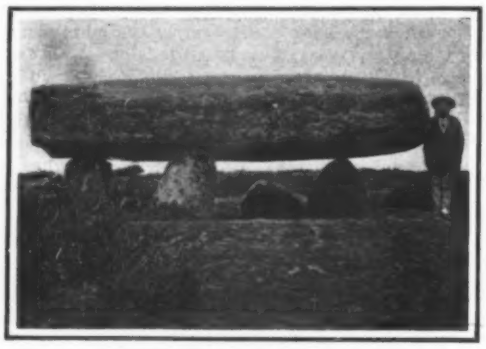


Fig. 1.—A DOLMEN AT LOCMARIAQUER IN BRITTANY.

These monuments can make no claim to artistic beauty, although they produce a very powerful impression upon the traveler who beholds them in their splendid isolation in leafy forests or on lonely moors. In the ruined temple of the sun at Stonehenge, near Stratford, in England, however, a circle of columns remains standing, which yet produces the effect of beauty as well as that of power (Figs. 4 and 5). The erection of these structures required long periods of time and gigantic exertion of force. How they were erected, we do not know. It is certain, however, that both time and men were cheap, and every conjectural explanation should take account of this fact. In the following attempt to explain the erection of these monuments, it is assumed that the megalithic builders never dreamed of actually lifting great weights. The final result is the same, whether a column is constructed by raising the covering boulder to the tops of the supporting pillars, or by placing the pillars under the bowlder as it lies on the ground. The latter object may be accomplished by excavating the earth in the places where the pillars are to be set in, after they are all in place, removing the earth from between them and around them to a considerable distance. The dolmen will then stand alone, and will give no evidence of the method by which it was constructed. The diagrams in Fig. 6 show four stages in the erection of a dolmen by underpinning the bowlder and removing the earth in this manner. Before the excavation is commenced, the roof-stones of the entrance colonnade could be rolled into place in contact with the bowlder and with each other. In a similar manner, a roof could be made of two small instead of one large bowlder.

The dolmen could, however, have been erected by another method, which is illustrated in Fig. 7. Here the columns are set at the end of a sloping bank of earth, along which the bowlder is rolled to the top of the columns, and the mound of earth is then removed.

The erection of a great pillar (menhir) was, in principle, as easy as the erection of a dolmen, but it required extensive preparation. The great monolith must also have been moved on rollers up a very gradual and uniform incline of earth, capable of sustaining a load far exceeding 100 tons, to a height slightly greater than half the length of the column (Figs. 8 and 9). In the middle of the steep front face of the earth bank, a groove was made which was continued at the bottom by a shaft penetrating into the solid earth as far as the finished column was intended to penetrate. The column was moved on wooden rollers, foot foremost, up the slope, toward this groove until its center of gravity passed the crest of the bank, when it tipped and glided into the groove and shaft. Hence the shaft must have been wide enough to allow the column to fall freely, and long enough to allow it to swing into a vertical position (Figs. 8 and 9).

It may be objected that the column would topple over forward, but this objection can be easily proved to have no weight. Fig. 10 shows a photograph of the result of planting a column by this method, the column being represented by a bottle filled with water, and the bank of earth by a cigar box. When the bottle was moved bottom foremost over the cigar box until it tipped and fell over the edge, it always assumed the position shown in the illustration. The light books there shown sufficed to prevent it from falling forward. The bottle simply displaced the books a little and then swung back to its vertical position, and never showed any inclination to fall sidewise. Indeed, the bottle immediately assumed the upright position in three of about twenty experiments which were made without using the books. Altogether, the same bottle served for more than one hundred experiments without sustaining any injury.

Fig. 2.—A MENHIR AT CADIOU IN BRITTANY.

While, with a sharp-edged earth bank, the column swings freely through the air to its final upright position, with a round-edged bank (Figs. 11 and 12) the column would glide into the shaft in an oblique position, and could then be set vertical by the use of poles and levers. This method of erection is not quite so simple and daring as the former, and was very probably the method adopted. In the former method, the entire base of the column strikes the bottom of the shaft at once, and the shock of the impact can be diminished by partly filling the shaft with mud or turf. In the other method, on the contrary, the strain comes upon the edge of the column, which might easily have been injured. Hence some danger attended both methods. Perhaps the Locmariaquer menhir was broken in the attempt to erect it.—Prometheus.

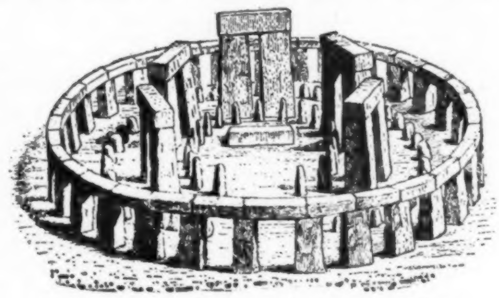


Fig. 5.—STONEHENGE, ACCORDING TO BROWNE'S RECONSTRUCTION.

THE ROLE OF VISUAL FUNCTION IN ANIMAL AND HUMAN EVOLUTION.*

By George M. Gould, M.D.

When scientific interest first appeared it concerned those things farthest removed from the observer and of the least vital importance to him. During thousands of years the intellect gradually approached the consideration of the human being himself. Astronomy was the first of the sciences; then man discovered his own world. The beginning of biology came nearer home than geology, and through numerous approaches and standstills man finally reached his own body. The bones of that body were his first care, then physiology was found; psychology is now emerging. It is natural that the law which expresses the order of the diverse kinds of discoveries should hold when applied to the stages of progress in each individual type. It follows that in zoology and physiology the nearest and most important conditions which have brought about the exclusion of the unfit have been deferred for final finding and scrutiny, and we are now entering upon this last stage of accounting.

Hitherto the interaction of organism and environment has largely summarized the philosophy of bio-

* Paper presented to the British Association for the Advancement of Science and here reprinted from the Medical Record.

Fig. 3.—A MENHIR AT MERSINA IN ASIA MINOR.

Fig. 4.—STONEHENGE SEEN FROM THE WEST. THE STONE OUTSIDE THE CIRCLE IS THE SO-CALLED ASTRONOMICAL STONE.

logical development, followed at once by the admission that the environment is the predominant factor, and that the individual organism has but little influence upon the outside circumstance. The truth seems rather to be that, when rightly estimated, the human organism, as a whole, has largely made its own environment, and that civilization is progressively taking almost entire charge of it.

With this re-creation of the environment by humanity will come the recognition of the hitherto unseen truth that the most intimate and influential part of the environment is man's own body. Following this, it will also be admitted that the individual variants of organs, such as imperfect senses, traumatisms, diseases, etc., not to be accounted for by heredity, are powerful factors in making misfits and unfits of such organisms and thus excluding them from the phylum.

Whether the controversy concerning the inheritance of acquired characteristics shall be settled in one or another way, the speediest and surest method will be by the study of the action of the inheritance of disease. And especially as to those diseases which depend upon ametropia. Here is an astonishing mass of

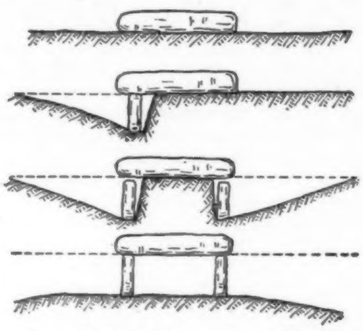


FIG. 6.—FOUR STAGES IN THE ERECTION OF A DOLMEN.

evidence collated and placed in the hand. If it were used, the controversy would soon be illuminated. The people, rightly or wrongly, also believe that they "inherited" their headaches, sick-headaches, and morbid nervous diseases. A very little careful testing would prove or disprove both the scientific and the popular faiths. Thus, again, as always, what is good science is good benevolence. Pathology would soon settle more scientific and social problems than normal physiology or morphology.

This gives warrant for criticism of that too common prejudice which excludes pathology from scientific consideration. It would rather seem that all other factors combined hardly equal in efficacy that of disease in excluding the unfit from genetic function. The morbidity and mortality rates, even among animals, and certainly in human life, markedly govern the evolution and characteristics of the phylogeny.

If so much is admitted, then the function of vision has been a strangely overlooked factor in the development of fit and unfit, and in shaping animalian and human trends and products. This is because vision is the most directional component, the *sine qua non*, indeed, of that part of the environment called the body;

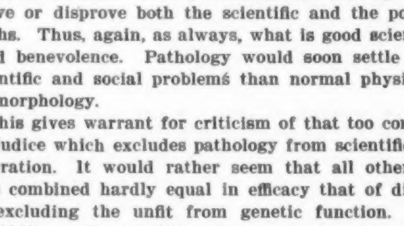


FIG. 7.—SMALL DOLMEN AT FALLINGBOSTEL IN (SUPPOSED) PROCESS OF ERECTION.

it intermediates between that body and the more external world; between man's hands and himself; between his mentality and his corporeality. The reason for the preponderant rôle of the eye in the development of unfitness lies in the difficulties encountered in its creation and present perfecting. It has been the severest task of the biological process, and its imperfections are still a vast and growing source of the imperfections, characteristics, and failures of that process itself.

These difficulties may be roughly classified as those which relate to:

1. The embryology and optics of the eyeball.
2. The rôle of vision in the development of self-motility of the body.
3. The progress from divergence to parallelism of the optic axes, or from laterality to forward-looking.
4. The adaptations consequent upon the assumption of the vertical posture of the body.
5. The development of the shading mechanisms of the retina.
6. The struggle against astigmatism and other forms of ametropia, accommodational failure, cataract, ocular, and systemic disease.

1. In view of the fact that the ether is the chief medium connecting organism and environment, the knowledge and utilization of the external world was possible only through the development of visual function. The fundamental difficulty in the construction of the eye was to devise a mechanism which should react instantaneously, accurately, and for a lifetime to a stimulus hundreds of millions of millions slighter

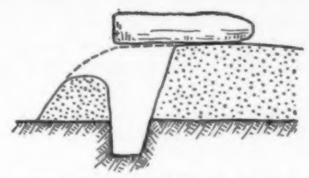


FIG. 8.—A COLUMN ABOUT TO TIP OVER THE EDGE OF THE BANK AND DROP INTO THE HOLE AT ITS BASE.

in kinetic energy than that, for instance, of sound waves. There is a keen suggestion of this difficulty shown by embryology. Within a few weeks after fertilization, the ovum, nearly synchronous with the differentiation of muscular tissue, shows the eyes in beginning formation. That it is so early, and that eye and muscle develop at the same time, is strikingly significant, for neither alone, certainly not the muscular system alone, would be either possible, or of use. *Ubi motus ibi visus!* If "the ontogeny repeats the phylogeny," then the long stage of coincident embryonic evolution of the visual and muscular organs demonstrates an amazingly long period during which the difficulties and imperfections of either, or of both, were overcome. Those individuals and types in which these imperfections were the greatest must have been those excluded from the phylum because of unfitness. The undoubtedly greater difficulty of device in making the eyes renders it clear what delayed the perfecting of bodily mechanism, and why the unfit were preeminently those that were visually unfit.

A still more significant fact is that the brain comes out to see: cerebral substance is pushed outward to make the essential ocular structure, the retina. In no other instance is this embryonic process the same; and the reason seems clear that in no other is such a procedure necessary; the mechanism could not be de-

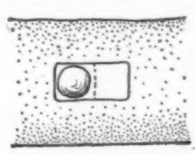


FIG. 9.—BANK, COLUMN, AND HOLE SEEN FROM ABOVE.

vised as in the other organs and senses with the crude and refractory materials at the disposal of the organismal artificer. It was only with its own highly differentiated and complex cerebral substance that the complex and differentiated retina could be constructed and kept in life and repair—as the food of the babe is part of the mother's own tissues. The number of medullated nerve fibers of the human optic nerve is about 438,000, the number of retinal cone cells at birth between 3,000,000 and 4,000,000. Noteworthy is the fact that the creation of the eye at birth is incomplete; the number of cones in the adult is double that of the babe. The number of retinal rods has been estimated as high as 130,000,000. Upon these hundred million rods and cones, as if upon so many bunched finger-tips of a blind man, is laid the warm picture, made by light, of the external scene, and the blind man sees, his crowded and extended fingers making, as it were, an eye.

The sensitive film of this living camera had to become a perfect mechanism of color-photography; had to be resensitized in an instant for a million pictures a day! All the adventitious peripheral structures—cornea, aqueous, crystalline lens, and vitreous, had also

FIG. 10.—PHOTOGRAPH OF A BOTTLE OF WATER STANDING ERECT AFTER TIPPING OVER THE EDGE OF A CIGAR BOX.

to be made and kept transparent without the usual red-blood corpuscles always necessary elsewhere. Such are a few of the difficulties encountered and overcome. Failure in any part inevitably threw out the individual, good in every other way, as unfitted to survive. If at the present time millions are thus excluded, what must have been the havoc in the animalian and savage past?

2. Adaptation to the environment and utilization of it by the organism was and remains impossible without the intermediate of self-motility. But this was likewise impossible without the prerequisite of vision to make the outside world known. Hence the synchronous and coincident development of the ocular and muscular systems. The accurate spacial and topographic representation of the objective world by the visual mechanism, and intimate, instant, and dominating guidance of all motor centers by the ocular picture, thus became primal necessities. There is scarcely an organ, surely no striated muscle, that is not directly or indirectly the servant of the eye. From animalian fight, shelter-seeking, and food-hunting, to civilization's latest cunning and devising there is an ever-increasing interplay of seeing and doing, until now vision seems to have vastly outrun execution. With every cerebral motor center awaiting, instigated by and obeying the guiding vision, how numberless the failures due to a hundred diseases and faults of mechanism! The present world of the sick, hurt, and prematurely dying are innumerable illustrations of the excluded unfit.

3. The optical axes, in the lower orders of the Mam-

FIG. 11.—EARTH BANK WITH SHARP EDGE.

malia, began with almost absolute divergence and proceeded toward parallelism through the progressing orders, until with the Simiæ and Man there is perfect parallelism.* The large range of the axes in the Marsupialia (from 75 deg. to 30 deg.) is suggestive, especially when that of the Carnivora is found to begin the overlopping at about 50 deg. and reach to within 5 deg. of the perfect parallelism of Simiæ and Man. The approach of parallelism may be looked upon as a kind of Ariadne clue through the maze of phylogenetic ascent. If we translate the approach toward parallelism, and its attainment by Simiæ and Man, in terms of the struggle for existence, we gain a new insight into the profound significance of the lateral and of the forward-looking kinds of vision. The greater the self-motility and the fighting ability, the greater the approach of the visual axes to parallelism, the large and small Felidæ being nearest that of the Simiæ and Man. The difficulty in attaining parallelism is, of course, due to the necessity of great modifications, not only in the bones of the face, but even in those of the skull, the transplacing of the orbits, etc. The more divergent the axes the more gregarious, the more cowardly the animal. The common hare has 85 deg. axes. What a vast, and astonishing influence, therefore, has this factor had in the entire evolution of the fit, the exclusion of the unfit, in animal psychology, in morphology, indeed, in every zoological inquiry! It seems to have been unsuspected.

FIG. 12.—EARTH BANK WITH ROUNDED EDGE.

4. In the same way the significance of the change in bodily posture from horizontality to verticality, effected in man, appears to have escaped proper recognition. It is man's most striking and differentiating characteristic, distinguishing him from the rest of the zoological world. Has it been effected without a long and mighty struggle, without profound influence upon the victors, without exclusion of great numbers of the vanquished? Concealed by the slow process of ages we do not see the profound changes that occurred during the passage from horizontality to verticality of body. Think of placing a habitually horizontally-bodied animal on his hind legs only, his body erect, and one has a picture of what immense modifications of morphology, physiology, etc., must follow before the abused animal, if he lived a thousand years, would see and act with any approach to our "natural" seeing and acting. The Marsupialia and other relics of the half-way accomplishment of verticality exhibit most significant traces of the sorry ill successes. They may be described as the forty-five degree zoological failures. It would have been quite impossible to create visual organs equally well adapted to alternating hori-

* See Johnson, "The Mammalian Eye."

zontality and verticality. Hence the comparative failure and absence of numerous species even of the 45-deg. types. The marsupial pouch is a necessary device to meet an exigency caused by the constriction of the pelvic outlet, which is due to the induced massiveness of the bony pelvis, and this a result of body-weight resting upon these bones. The ovum soon after fertilization must be extruded at an early stage of gestation. In the kangaroo a special osseous support of the pouch is required—itself a hint of the failed struggle of the intermediating unfit. The primary necessity which drove the Simians (and the Marsupials, also, for that matter) toward verticality was tree climbing, for food getting partly, but more to escape from enemies. But *pari passu*, one should not forget, came the required perfection of ocular function with parallelism of the ocular axes.

Out of many great changes consequent upon the assumption by Simians and Man of the upright posture I select several illustrating the difficulties and dangers encountered in fixing and making permanent the habit.

When we medical men do not know the etiology of a disease we take refuge in the solemnly chanted words: diathesis, neuropathic diathesis, neurasthenia, hysteria, etc. It may be said that in the human race spinal curvature is due to scoliotic diathesis. In a great American university, of about 1,200 freshmen examined by experts, 80 per cent had lateral spinal curvature. The proportion does not probably differ in any occidental country where school children are taught to write in the way advised with us. These 60,000,000 of United States folk have, therefore, not only the scoliotic "diathesis"; they have the scoliotic fact. The support of two-thirds of the body weight by a single upright rouleau of ligatured bones, like that in the lumbar region, is an enormously expensive and hazardous proceeding. And yet accurate verticality might still be usually preserved if it were not for two ocular factors of mischief.* The morbid occidental writing posture, due to ocular function and malfunction, together with some peculiar axes of astigmatism, are the active and sufficing causes of the great majority of cases of lateral spinal curvature. None may measure or calculate the part played by this astonishingly frequent scoliosis in the making of unfitness, and in swelling the morbidity and mortality rates.

Another cause and result (both peculiarly interwoven, as always in such proceedings) of permanent verticality of the body-trunk consists in the freeing of the front feet and legs from the function of walking and running, and making them into the manipulating tools without which *Simia* could never have become *Homo*. Immediately and synchronously in development came the evolution of sign language, and of articulate language itself. The word digit, and the Roman numerals representing the fingers held up, are the living remains and evidence of the early stages of this evolution of the front foot, paw, and hand as a tool, and also of language formation.

According to the admitted localization of the cerebral centers controlling muscular acts, the center for articulate speech is located upon one side of the brain, adjacent to the center for writing. Articulate speech is a single not dual act, and hence its center could not in one person be bilateral. For the same reason neither could the writing center be double. Consequently the writing center and the speech center are close neighbors, located in one cerebral hemisphere, the left in the right-handed, the right in the left-handed. The expert task of writing is carried out by the right hand, and because what is written is language (even now writing is correlated by the schoolboy with whisper and lip motion) the contiguity of the centers in the single third frontal convolution is a necessity.

But there is now a new factor of great importance subtly introduced into the whole affair—that of a choice of one hand or of the other for special tasks. For certain delicate and expert ones the dextral hand was chosen in about 94 per cent of men and women, in the other 6 per cent the sinistral. In either case the less expert hand is the helper of or the holder for the other. Among animals there is no trace of such differentiation into right and left, because, of course, both front paws are equally and almost solely used for walking, etc. In the four-footed, horizontally-bodied animal, to the divergent right eye, looking to the right side, was allotted the task of seeing the world to the right, and particularly of placing the right front foot. To the similarly divergent left eye was given the left side to watch out for and the left foot to place.

There was in mammalian beginnings little forward looking, because parallelism of the visual axes was ages ahead, and could not be complete until the front legs and paws could be relieved of locomotion, and, with the upright posture, put to manipulative uses. Such an animal blinded in one eye was thus quickly excluded as unfit. Ophthalmic disease and traumatism, of course, was more and more frequent as we go back to more remote and primitive conditions and habits.

* Helpful is the often overlooked fact that we spend one-third of our lives in bed—in the old horizontal position.

With the vertical posture came right-handedness and left-handedness, came parallelism of the optic axes, came downlooking, overlooking, outlooking, and forwardlooking, and the immense and sudden leap from monkey to man! Necessarily there were besides those heretofore bespoken, a hundred vitally important modifications, extensions, and perfectings of function and structure which will long occupy the attention of future scientists. Of these we are here concerned with the ocular ones only; but what a vista is opened wherethrough we see the fittest to survive are often those only that are visually fit, and those excluded are they visually unadapted to the new conditions. Because, forget it not, the greatest perfection of visual function, from the day of assumed verticality, becomes the chief of all the agencies of progress. Ingenuity and intellect, speech, and writing, and printing, and language itself, could not follow without vision. The letters of the alphabet are conventionalized pictures, that is, ocular photographs; and memory, without which there can be no personality or individuality—memory and experience, are but a gallery of such photographs.

The latest complication and modification of visual function is a direct result of right-handedness; the eyeballs being placed 50 or 60 millimeters apart necessarily see two different pictures of an object. Therefore with delicate and dangerous tasks one eye must dominate. From the most primitive times the right foot or hand has been directed by the right eye, the left foot or hand by the left eye. With the evolution of right-handedness, upon the right eye has devolved the duty of guiding in the more expert tasks. Hence the inevitable correlate of right-handedness is right-eyedness (dextrocularity), and of left-handedness it is left-eyedness. Indeed, I think that the precedent right-eyedness forces the choice of the right hand as that for the more expert task, writing, sighting a gun, etc.* The infant chooses the right hand with which to reach out and grasp things because it is right-eyed. All army regulations, uniform since Xenophon, cannot make the left-handed soldier into a right-eyed one. The question of right-handedness and right-eyedness has been a mighty one in all history; all military life, drill, and maneuver, chivalry, single combat, the rule of the road, etc., etc., are commanded by it. All mechanics, tools, etc., must consider it well. Early railway locomotive building worked for years aimlessly at the unknown problem of right-eyedness, until it was found out, none knew why, that the engineer must stand or sit on the right side of the boiler. Railway wrecks still occur because three double-track roads pass to the left.

So advanced is the fixation of right-eyedness that, in the right-handed, the right eye will retain its function of right-eyedness despite a far greater degree of amblyopia than in the left, caused by late arising disease or ametropia. The left eye is far more subject to disease than the right, and is the one usually thrown out of use by ametropia, heterophoria, etc. There are, I suspect, a million Americans whose right eye is the only useful one. Were it not that the nose hides from the right eye a considerable part of the world to the left side, it is probable that the trend toward a single or cyclopean eye would be greater than it is at present.† In the light of the localization of the speech and writing center, and of the origin of right-handedness, the blunder of the ambidexterity-monger is as maleficent as may be easily imagined. Every left-handed child taught by him to write (and that is all he tries or is able to do) with the dextral hand is thereby sadly and permanently injured.

5. If one is able to fix the visual axis of one eye, without movement or winking, upon an illuminated object, it soon fades out and disappears. The sensitive film, the retina, can hold the image but a second or two. Constant change of stimulus, of the scene or image, variation of light and shade, etc., are necessary to retinal resensitization. The fact points to the fifteen mechanisms I have described which bring about this change of place, of stimulus, and of regenerating shadow.‡ Observation shows that the lower mammalia have eyes inferior to man in visual power. The widely opened pupils and lids prove this fact even if other evidences were not manifest. All birds, nocturnal prowlers, etc., must see upward and widely about, so that the shading mechanisms of the human retina are necessarily absent. That the numbers of rods in the adult are twice those of the infant suggests far greater complexity and responsiveness of the visual function of man as compared with that even of the higher animals. It also prophesies further progress. But the shading mechanisms, in their totality, so necessary in man, are themselves demonstrations that in the ascent toward humanization and civilization the individuals superiorly equipped in these respects won in the struggles over those with less protected retinas.

* I have had two left-handed patients who, compelled to shoot from the right shoulder, could take aim only when they depressed the right eye below the gun-level, and sighted with the left eye.

† In reference to the disadvantage of a high nasal bridge in man, it should be noted that Oriental types have a higher wall between the eyes than the Teutonic races, who are now the chief carriers of an advancing civilization. In the statues of the classic Greek and Roman sculptors the line of the nasal crest joining the tip of the nose and the forehead is a straight one. The Jew of to-day illustrates the same inheritance, or, indeed, that from a more remote ancestry in which the bridge bowed forward or outward. With us, instead, there is a marked depression between the eyes, which will probably increase, and thus will be avoided some of the disadvantages of the trend toward monocularity.

‡ In birds the pecten, I suspect, unites in itself the most of these mechanisms, the large floating mass of waving vessels, with every movement of the bird's head, securing shadowing of one macula, while exposing that of the other eye. Birds, nocturnal prowlers, and those animals with habitually widely opened lids have no astigmatism and thus have this compensation for their less sensitive retinas, etc.

Winking excepted, the chief of the human shadowing mechanisms is the position of the border of the upper lid at the upper edge of the pupil, followed by its instantaneous descent over the pupil in every act of winking. While hovering above the border it is shading, when dropping over it, it is wholly blackening the retina. Its position is a consequence of the vertical position of the body and head, to shield the retina from the unused light above which would otherwise flood it with stimuli and thus drown photographic definition.

This inobviable necessity of the habitual placing the upper lid at the upper border of the cornea of vertical-bodied man brings with it a sad new evil, less pathogenic than would have been the excess of light, it is true, but still of enormous disastrous results of civilization. It is the chief cause of astigmatism. The cornea is warped by the pressure of the lid and one radius of its curvature is rendered greater than that at right angles to it. The retinal image of an astigmatic cornea does not therefore represent the true conditions and topography of the external world. The cerebrum is the organ of the inherited average of all past experience of approximately perfect visual images. The widely variant and morbid retinal stimulus passing through the 400,000 optics nerve fibers to all parts of the cerebral switchboard, meets the infinitely complex but perfectly normal, receiving and relaying mechanism. Resultant abnormalism of sensation, as to shape, color, accuracy of topography, etc., confuses the sensorium and makes external action, based always upon vision, hazardous and ill adapted for the act and for the individual. The individual must succumb, the race must persist. It is all a clear example of the truth that the body is really a part of the environment. Compounded with the other forms of ametropia as it usually is, we have the greatest of all environmental limitations to the progress of civilization. Almost every human eye has little or much astigmatism—there is not an optically or mathematically perfect pair of eyes in the world—and a small defect of shape may be more harmful and unfitting for the struggles for existence than the greater ones. The only miracle of ingenuity impossible for the ocular mechanic seems to be to make an eyeball true to within 1/200 or 1/300 of an inch. That fault of shape or measurement is constantly excluding millions from work in late social development, and differentiation of function.

I beg you not to think or characterize this as the visionary imagining and exaggeration of specialism or of ill-balanced judgment. The reception of discoveries, medical or purely scientific, of the past warns us that the greatest advances often spring from overlooked little things, and that prejudging is unsafe. Even as a military organization the German nation has far less validity than is necessary, because of myopia. The greatest ocular handicap, after astigmatism is the hyperopic eyeball, well adapted for old-world life tasks, but most ill-fitted for the inordinately demanded near-work of civilization. Astigmatism is the chief cause of myopia and of cataract. Astigmatism is unavoidable, but all its effects may be easily avoided. Accommodational failure, or presbyopia, is also inevitable, but its evils may also be circumvented. Handed down as a tradition of the past ages, an absurd premature senility and a long-drawn-out, useless old age have become so customary that one may hardly recognize that both are the needless results of unnecessary eye strain.

The catalogue of ills and the exclusions of the unfit, because of ocular malfunction, are by no means ended. The president of the British Medical Association officially emphasizes the testimony of hundreds of other careful scientific medical men that vast numbers ("millions," he says) suffering with incapacitating headache, produced by eye strain, have been relieved by spectacles. The Governor of Massachusetts goes much further in his inaugural address, and a famous surgeon of New York city says he avoids the majority of abdominal operations by sending patients to oculists who cure them with glasses. The great majority of the diseases of the world's sick and prematurely dying began in functional disease, which is, of course, simply abnormal physiology. The larger number of aberrant physiological processes are directly or indirectly due to slight imperfections of measurements and shape of the eyeballs. Eventually they phase themselves into those mysteries of medicine called migraine, headache, sick

headache, functional diseases of the digestive organs, lateral spinal curvature, kyphosis, nervous and mental diseases, such as insanity, much criminality, hysteria, neurasthenia, epilepsy, even suicide. There is an abundance and a growing mass of testimony that these diseases are very largely the consequences of morbid ocular function. Only the healthy are admitted to the future phylogeny; the diseased are unfit. It is easily possible to eradicate the diseases caused by eye strain, and when the opportunity is realized, the number of medical men, colleges, and hospitals will be reduced by more than a half, the morbidity rates and mortality rates equally decreased, while the number of those endowing the future will be correspondingly increased.

THE AGE AND GROWTH OF FISHES.

THE RESULTS OF RECENT MARINE INVESTIGATIONS.

The valuable publications issued by the Conseil Permanent International pour l'exploration de la mer have recently been increased by a very interesting report, by Dr. Johan Hjort, showing the results obtained through the Norwegian fishery and marine investigations 1900-08. Dr. Hjort, who is the chairman of the so-called Commission A, appointed in 1902 by the International Council for investigating the migrations of the cod and herring and their influence on the fisheries especially in the northern parts of the North Sea, is our chief authority in this special field, and in the volume before us he lays down the practical and scientific results of the expeditions which under his leadership have been carried on for a number of years on board the steamship "Michael Sars," the first ship exclusively built for maritime researches.

One of the most remarkable results of these expeditions is the solution of the problem of the age and growth of fishes, which appear from the size and growth of their scales. In this connection we beg to reproduce the following passage from the report written by the Belgian expert Dr. D. Damas:

The scales of gadoids (cod family) have a very regular concentric structure. Their growth consists in the addition of new elements to the edge in the form of small ridges. The size of these ridges varies with the rate of growth, large broad ridges being added when development is rapid, small ridges when it is slow.

A complete cessation of growth is indicated on the scale by a dark ring. The number of dark rings corresponds with the number of periods when growth has been feeble; and as it has been found that these periods are generally coincident with the cold season of the year, it follows that the number of rings shows the age of the fish. When we add that the size of the ridges indicates the rate of growth in the different periods of the year, it will be seen that we have in the scale an excellent proof not only of the age but also of the progress of development.

The importance of the scale as an indicator of development lies chiefly in the fact that from the structures of these organs we can calculate the size of the fish in preceding years. For the size of that portion of the scale which is limited by each of the so-called winter rings is directly proportional to the length of the fish at the conclusion of the corresponding period of growth.

The fishes of the cod family which have been investigated according to this method are cod, saithe, haddocks, whitings and pollack; and in the case of the first three, to which we have specially devoted our attention, we have collected from the whole of the Norse coast a material thoroughly representative of the different sizes.

One of the most important results of these researches has been the discovery that a number of year classes may be found together in the same shoal of fishes. Out of 654 caplin cod, caught on the Finmark coast June 7th, 1907, the majority, with ages up to five and six years, had never spawned. Again among the spawning cod have been found cod up to eighteen and twenty years which undoubtedly had spawned at least twelve and fourteen times.

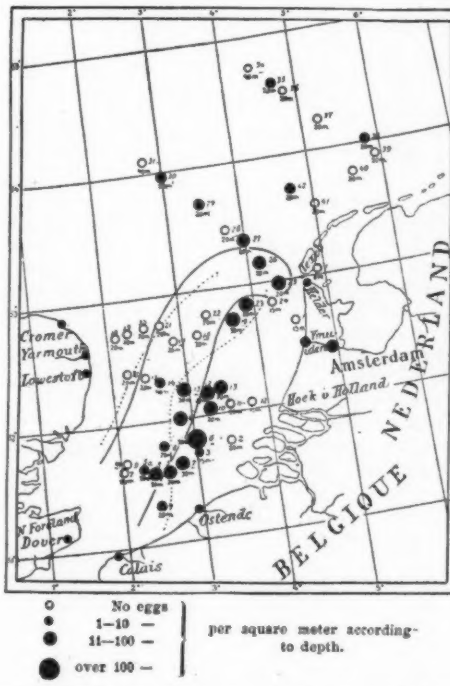
Similar analyses of a comprehensive nature show that the proportion between the different year-classes may vary considerably, and that over extensive tracts of sea and ocean certain sizes and age-groups may be almost altogether absent. A good instance of this is to be found in the composition of the haddock assemblage in the Skagerack during 1906. We examined 1,289 specimens caught along the edge of the Norwegian Channel at various places between Arendal and Fredriksværn. Their ages were ascertained to be as follows:

Age, years	1½	2½	3½	4½	5½	6½	7½	8½	10½
Spawned in	1905	1904	1903	1902	1901	1900	1899	1898	1896
Number of fish	5	621	45	146	355	85	27	4	1
Percentage	0.4	48.2	3.5	11.3	27.5	6.6	2.1	0.3	0.1
Av. length, cm.	22.5	27.8	34.1	42.1	47.1	53.6	58.4	66.2	64.0

From this it appears that the individuals spawned in 1902 and 1903 were proportionally very few. These fish, which were then in their fourth and fifth years respectively, had a length of 25 to 45 centimeters; and it was remarkable how poorly they were represented in the large quantity of specimens examined.

These differences in the proportional quantities of the various age classes cannot but have great influence upon the fisheries. They are the result either of variations in the exuberance of spawning or else of increases or reductions in the accession of fry due to the agency of ocean currents.

Investigations have shown that fish of the same age attain a quite different size at different localities, and this is due to corresponding differences in the mode of growth caused by different conditions in the climate of the sea. Accordingly, among individuals of the same species we may expect to meet with considerable dissimilarities between those derived from southern and those from Arctic waters. Saithe, for instance, on the Skagerack coast, attain a length of 20 centimeters at the conclusion of their first year, whereas saithe of the same age do not on an average exceed 10 centimeters in the north of Norway. This difference in growth is clearly indicated by the scales. In the first place the scale of the Skagerack saithe is larger than that of its more northerly relative; and



DISTRIBUTION OF THE EGGS OF THE COD OVER THE SOUTHERN PART OF THE NORTH SEA.

secondly, it has broad regular ridges over the whole scale-plate, whereas the saithe from the north of Norway has on its scale a series of broad ridges that are followed by a ring with small crowded ones.

The structure of the scale of the North Sea cod is so regular that it is extremely difficult to count the year rings. The winter rings, on the other hand, of cod from the north of Norway (skrei and caplin cod) are exceedingly distinct. This difference arises from the fact that the period when growth is feeble or entirely ceases lasts much longer in northern than in southern waters. Hence we see that the scales are able to tell us whether the fish has lived amidst arctic or southerly conditions.

Similar differences are noticeable when we examine fish from different depths. For the period when growth is stagnant varies slightly with the depth. In the upper water layers this stagnation period coincides with the winter on land; but deeper down it will be found that both stagnation and the resulting winter ring commence later, a phenomenon which can quite easily be reconciled with the fact that winter cold sets in more tardily in the lower layers. It may happen, for instance, that fish from a depth of about 200 meters in the Skagerack have only just commenced their growth in July. The study of this phenomenon will possibly help to demonstrate that the same species of fish may have its reproduction period at different seasons in different localities.—Farmand.

An extraordinary accident occurred recently on the Willebroeck Canal, one of the great artificial waterways of Belgium. About eleven o'clock some boatmen on the canal noticed that the level of the water was sinking, and warned the authorities. An explanation of the unusual occurrence was soon forthcoming. At a point between Brussels and Vilvorde (about seven miles north of the capital) the canal passes over the river Senne, with which it is connected by a feeder conduit, built on the siphon principle, and it appears that the sides of this conduit collapsed without warning, allowing the water to rush unchecked from the canal into the river. Steps were immediately taken to isolate the section of the canal where the break occurred, but not before the level of the whole canal had fallen about six feet. It is reported that the canal has been dammed.

THE EFFECT OF CARBON DIOXIDE ON FISHES.

In mammals the effect of carbon dioxide is exerted chiefly upon respiration, both the frequency and the depth of which are increased, until finally a condition is produced which is called dyspnœa, or loss of breath. As even small quantities of carbon dioxide affect respiration, it is generally assumed that the carbon dioxide of the blood, the quantity of which depends upon the proportion of carbon dioxide in the surrounding atmosphere, affects the nerve center which calls forth and regulates the movements of respiration, so that carbon dioxide represents a physiological stimulus for respiration. For example, a proportion of carbon dioxide equal to five per cent or less of the inspired air merely stimulates human respiration, but if the proportion is increased to eight per cent, a state of stupor is soon produced, and this condition is followed by a deep narcotic sleep which ends in death. Similar toxic phenomena are produced in other mammals, but they have not hitherto been observed in fishes. It has been assumed, therefore, that the respiration of fishes is essentially different from that of higher vertebrates. Dr. Reuss has carried out an elaborate series of experiments, at the Munich Biological Laboratory, on the respiration of rainbow and brook trout, carp, and tench, which prove that in these fishes carbon dioxide acts upon respiration as it does in mammals, so that there is no essential difference in the respiration of different vertebrates. There does not appear to be even any qualitative difference in the action of carbon dioxide on the different species of fish on which the experiments were made. In all of them the succession of toxic symptoms was the same: restlessness, dyspnœa, stupor, transient followed by permanent lying on the side or back, failure of almost all reflexes and, finally, death. In the state of dyspnœa both the frequency and the depth of respiration greatly exceed the normal. The gill covers, which in normal breathing scarcely open, now move violently, the mouth is widely opened and protruded forward, and it executes snapping movements for the purpose of taking in large quantities of water and forcing it through the gills. When the percentage of carbon dioxide is increased, movements of shaking or spitting are observed. The fish with widely opened mouth moves backward, shaking its head and exhibiting symptoms of nausea such as are observed in higher animals. When the dyspnœa is still more intense, the fish snatches mouthfuls of air from above the surface of the water and violently forces water through the gills. In this process the oxygen of the atmosphere is not breathed directly, as has hitherto been assumed, but the breathing water is enriched in oxygen by contact with the captured air. If the water contains coarse impurities, expulsive or coughing movements of the gill covers and the mouth are observed, by which the impure water is expelled from both mouth and gills. It is noteworthy that in fishes which have been killed by carbon dioxide poisoning the gill covers adhere closely to the body, while in fishes asphyxiated by lack of oxygen the gill covers are widely opened. Of practical importance is the observation that tench are comparatively little affected by carbon dioxide, and are hence able to feed in places where the water has become so impregnated with carbon dioxide, in consequence of putrefaction, that even carp cannot live in it. Trout begin to show symptoms of dyspnœa when the proportion of carbon dioxide in the water becomes equal to 30 millionths, carp with a proportion of 55 to 73 millionths, and tench with a proportion of 110 to 128 millionths. The permanent lateral position begins with trout with a proportion of 147 millionths, in carp with 257 millionths, and in tench with 440 millionths.—Prometheus.

ENGINEERING NOTES.

The success of the mono-rail system for carrying freight and passengers is largely a question of finding a satisfactory type of carriage, and experiments are now being made in connection therewith on short lengths of roads in India. The mono-rail system is believed to possess great value, because of its simplicity and cheapness of construction, for military purposes on mountain roads.

Another section of the Panama Canal has been completed. It is situated near Matachin, just below Gamboa, where the Chagres River intersects the canal route. At this point the river makes a deep bend, and it was necessary to cut through this bend to provide a channel for the canal. The cutting is about half a mile long, 500 feet in width, and has an average depth of about 45 feet. As soon as the rails are removed from the section, the Chagres River will be turned and allowed to flow through it, and the present bed of the Chagres will be used as a dumping ground.

The aerial torpedo for life-saving, invented by Col. Unge, has been tested on Sir W. G. Armstrong, Whitworth & Co.'s range at Silloth, on the Solway shore. The apparatus is designed to throw a lifeline from a ship in distress either ashore or to another vessel. The torpedo, the cradle from which it is discharged, and the line fit in a box 4 feet long and about 18 inches in width and depth. The torpedo is discharged from the cradle either by fuse or electric ignition of a charge of gunpowder. The tests showed that the torpedo could be sent with perfect accuracy a distance of 380 yards.

For the purpose of reducing the number of fires along the right of way in the Arkansas national forest the United States Forest Service has entered into a co-operative agreement with the Kansas City Southern Railway. It is a well-known fact that coal-burning locomotives are a prolific source of forest fires, particularly on heavy grades. Many of the most destructive fires have been caused in this manner, and incalculable damage done. The agreement between the Forest Service and the Kansas City Southern provides that the railroad shall clear its right of way of all inflammable material for a distance of fifty feet on each side of the track and burn over an additional 100 feet wherever necessary. A provision is made for the use of efficient spark arresters, and that fires shall be reported to the nearest station agent, who will notify forest officers and section crews. The maintenance of a forest service telephone line along the right of way will also be allowed. On its side, the Forest Service will patrol and supervise the clearing of the right of way, supply tools, and maintain and operate sufficient telephones as well as grant the railroad the timber free of charge, where it is necessary to clear the right of way. This agreement is for a period of ten years and has already been put into effect. Six telephones have been established along the line and excellent results are being obtained. The forest service will be glad to have similar co-operation with other railroads traversing national forests.—Railway and Engineering Review.

A pump operator named Alzial, attached to the French navy, has accomplished the seemingly impossible feat of raising water to a height of 50 feet with an ordinary suction pump. In the French navy, pump boats, or floating steam pumps, are employed to remove the water which accumulates in the holds of vessels which are out of commission and, consequently, out of steam. In some large warships the bottom of the hold is more than 30 feet lower than the porthole through which the pipe connected with the pump enters. In these cases the emptying of the hold is a difficult and tedious operation, especial difficulty being experienced in "priming" or starting the pump. One of the pump boats, however, always succeeded where the others failed, and the pump operator boasted that he could raise water to a height of 40 feet, if necessary. To test his powers the height was increased to 40 feet, and then to 50 feet. In both cases the pump was started and the water raised without difficulty. This remarkable result was obtained by the simple and ingenious expedient of inserting into the mouth of the pipe through which the water was drawn the shorter leg of a bent tube of smaller diameter, the longer leg of which rose above the level of the water in the hold and communicated freely with the air. By this means air was drawn in as the pump was worked. Hence the liquid raised was not pure water but an emulsion of water and air which, being of less density than water, could be raised to a greater height, by the pressure of the atmosphere. By increasing the proportion of air it is possible to raise water more than 60 feet in this way, but certain precautions must be observed. The speed of the pump piston must be greater than the velocity of ascent of the air bubbles, or the air will collect in the upper part of the pipe and the pump will lose its priming. The ascent of the air bubbles can be retarded by inclining the pipe, but there must be no sharp bends in which the air can accumulate.

ELECTRICAL NOTES.

Steps are being taken with a view to establishing wireless stations along the South African coast. The Natal government is negotiating with the imperial government on the subject, and it is proposed to erect a station on the bluff at Durban. The idea is to form a line of wireless stations between Delagoa Bay and Cape Colony, and a similar line of stations on the west coast.

In Norway and Sweden remarkable progress is reported to have been made in the commercial operation of electric furnaces. Arrangements have now been completed in connection with the Tröllhatan water-power works for the installation of three electric furnaces for the production of pig iron. Each furnace, it is stated, will be capable of producing 7,500 tons of iron per annum.

An influential committee has been formed at Chamonix for the purpose of constructing a wireless station on the summit of Mont Blanc. The idea of the proposed installation is to provide means for summoning aid for alpinists in danger on Mont Blanc and neighboring peaks, and also to connect the Alpine districts of France, Italy, and Switzerland. It is understood, says Electrical Engineering, that there has already been a generous response to an invitation for subscriptions for this purpose.

One of the most important electrifications of standard gage railroad lines in Europe at present is the project for the Hungarian state railroads on the section between Fiume and Moravicza. It is proposed to utilize for this purpose the large water falls which lie near the town of Zengg. They are owned by a private company who has already made overtures to the State for a supply of current. An electric plant of 30,000 horse-power would be erected here, and it would supply the centers of Fiume, Trieste, Abbazia, and the coast. It is stated that a large company has already been formed at Paris for promoting the enterprise.

The Bavarian government has drawn up a report on the amount of available hydraulic power in that kingdom. Acccording to the present data, the country contains water courses which have a combined value of 300,000 horse-power at the least figure. Among the streams which are best to be utilized at present in order to compete with steam on an economical basis are the Alg, the Walchensee, the Isar, and the Reissbach. For the first two streams the report estimates the supply at 45,000 and 56,000 horse-power respectively, but this is a most conservative estimate. Both the Bavarian and Baden governments are looking forward to the electrification of the railroads by this means.

It is often assumed tacitly, and, indeed, stated also in text-books, that Ohm's law will hold for electrolytes. That this is not strictly correct was pointed out many years ago by Kohlrausch. It is only immediately after closing the circuit of an electrolytic cell, before any concentration differences have been established, that Ohm's law can be applied; for Ohm's law presupposes the non-existence of a concentration gradient. During this non-stationary period of short duration relations prevail which, Kohlrausch demonstrated, resemble those required by Ohm's law. But conditions change soon owing to the migration of the ions, and during the ordinary stationary period of the electrolysis Ohm's law is not valid. Calculations have then to be based upon Nernst's equations, and though these equations lead to relations similar to those expressed by Ohm's law, they are by no means identical with them. The terms "stationary" and "non-stationary" periods are used by A. Eucken, of Berlin, in a mathematical paper on the problem published in the Physikalische Zeitschrift. In a certain measure the conduction of the current through electrolytes resembles that of conduction by gas ions, which obey Ohm's law for currents of low intensity. The deviations from Ohm's law are, however, not very great in the case of electrolytes, because the stationary period is very difficult to realize, owing to convection currents, at least for the main portion of the electrolytic cell, or trough. Near the electrodes the conditions are fairly stationary, but not further away from them. Yet it should be possible, as Grassi showed in 1903, with certain precautions, to produce an almost stationary concentration gradient throughout the trough, and by experimenting in this direction Eucken's formulæ might be tested.

In Switzerland in 1908, 16 persons were killed and 29 were injured by electric currents. Artificial respiration was employed successfully in 5 and unsuccessfully in 10 cases. There is reason to believe that it was not always applied with the necessary promptness and perseverance. The operation should be continued for at least 90 minutes before it is abandoned as hopeless. Of the 35 killed and injured persons, 10 were employees of electric companies and 16 others were engaged, at the moment of accident, in work connected with the electric system. The voltage was below 250 in 5 cases, between 250 and 1,000 in 5 cases, and above 1,000 volts in the remaining 25 cases. Most of the accidents were caused by the ignorance, imprudence, or negligence of the victims. The electrical system was seldom at fault.

TRADE NOTES AND FORMULÆ.

Argentine Metal (métal argentin.)—Composition metal for spoons, forks, tea pots, etc., consists of 85.5 parts of tin and 14.5 parts of antimony.

Photograph Paste.—Take of rice flour two tablespoonfuls, mix with water into a stiff paste, then add 600 cubic centimeters of water, constantly stirring, strain and boil with 2 grammes of gelatin and 30 drops of oil of cloves, until the mass flows like thin syrup. Then stir in 30 grammes of alcohol.

Phosphorus Electuary for the Destruction of Rats and Mice.—According to Krause, rub down 6 parts of phosphorus and 1 part of powdered sulphur, with 6 parts of cold water, add 2 parts mustard powder, 80 parts of cold water, 64 parts of sugar and 96 parts of rye flour. According to Dubois, mix together 2 parts phosphorus, 100 parts of hot water and 40 parts of wheat flour; to the cooled paste add a mixture of 100 parts of tallow, 20 parts of nut oil, and then 25 parts of sugar, and mix the whole carefully together.

Waterproof Placards.—Mix glue water with zinc-white, chalk or sulphate of baryta, and with this fluid coat the paper. As soon as it is dry, give it another coat of soda-waterglass, with some magnesia, and finally, expose the paper, for some days, to a temperature of about 770 deg. F. Sheets prepared in this manner can be left under water or exposed for a long time to moisture without anything written or drawn on them being effaced.

Waterproof Wagon Coverings.—In making them, dissolve, in 30 parts of water, 1 part of alum, and in another 30 parts of water, 1 part of sugar of lead. Pour both solutions together. As soon as the precipitate has settled, the clear fluid is poured off and in this the stuffs are worked until they are completely saturated. Having been allowed to remain for four hours in the fluid, they are taken out, drained, hung up to dry in the air or in a heated place, and after drying thoroughly brushed and ironed.

Preparation of Polish for Furniture, Picture Frames, etc., by Kunz.—To rub down the wood surface, amber is employed mixed with a preparation of 9 parts of rape flowers boiled with 4 parts of petroleum, and mixed with 1 part of benzine. The preparation with which the objects to be polished are to be rubbed and which produces a coating hard as glass, consists of 4 parts of ground bone glue in 5 parts of alcohol and 1 part of benzine. The oil-preparation required for polishing consists of 5 parts of juice of silbum marianum (St. Mary's thistle), celandine, etc., boiled with 4 parts of petroleum and adding 1 part of olive oil.

Deadening Powder for gold is a mixture of various finely-pulverized salts and consists chiefly of nitrate of potash, potash-alum, refined common salt, and sandiver. The composition very vigorously refines the surface, after it has been heated, on the gold coating, to the melting point. At the moment of melting, the velvety sheen of matt gold is produced, because the silver is removed by the powder. Deadening powder, as stated, must be used at a high temperature, at which the salts of which it is composed melt in their water of crystallization; this is effected in a pan of enameled faience at a temperature equal to the melting point of lead.

Phosphor Bronze.—Compared with ordinary bronze, phosphor bronze is said to possess greater elasticity and also a much greater absolute strength. Phosphor bronze is very fluid, can be cast at a lower temperature than ordinary bronze and more perfectly fills all molds, and for these reasons, as well as an account of its beautiful color, is especially adapted for casting statues, ornaments, house fittings, belt trimmings, etc. The softer kinds of phosphor bronze may be readily rolled and hammered. The composition of phosphor bronze, as we know it commercially, according to Stözel, differs materially; that containing the most phosphorus is the best. According to Bendy, a Künzel phosphor bronze consisted of 90.34 parts of copper, 8.90 parts of tin, and 0.76 part of phosphorus.

TABLE OF CONTENTS.